IAQ Management IEQ-1

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Establish high indoor air quality (IAQ) for the comfort and well-being of the building's occupants by minimizing the potential for poor air quality, and by establishing minimum IAQ performance and standards.

Action: Provide an Indoor Air Quality Management Plan which employs architectural and HVAC design strategies to establish minimum outdoor air quantities, chemical, biological and particulate source control and on-going air quality monitoring to achieve a positive impact on the overall indoor environment and well being of the occupants. Meet the requirements of ASHRAE Standard 62-2001: "Ventilation for Acceptable Indoor Air Quality", utilizing the Ventilation Rate Procedure.

Prepare plan in accordance with the requirements of NYSGBTC 638.7(d)(1,2 and 3). Draft the plan in accordance with the EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991 and EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998.

Related Guidelines: SEQ-1, SEQ-5, SEQ-6, EEQ-6, IEQ-3, IEQ-4, IEQ-5, IEQ-6, IEQ-7, IEQ-8, IEQ-9

LEED™ 2.1 Requirement: EQ Prerequisites 1 and 2. (See Submittal Template)

Introduction/Context

This credit uses compliance with ASHRAE Standard 62-2001 as its baseline requirement. ASHRAE Standard 62-2001 addresses minimum ventilation rates as well as indoor air quality levels that are intended to protect human health and well-being. There are three primary sources of indoor air quality (IAQ) contamination in buildings:

- Building 'loads' which result from off-gassing of the chemical components of construction materials and interior finishes, equipment emissions and related functional activities as well as maintenance materials and methods.
- Moisture intrusion, which creates conditions that support the growth of molds and mildew.
- Particulates, which enter the building in a multitude of ways, but primarily via the HVAC system, materials that shed, and/or through the operation of equipment.

The building occupants also contribute to the introduction of building loads and particulate matter through their clothing (dry cleaning chemicals, heavy detergent residue, fiber shedding, etc), perfume and personal bio-effluents, as well as dirt and dust particles brought in on shoes and clothing. Smoking, though now controlled in indoor environments in New York City, is a contributing factor to poor IAQ in many places.

Building Loads

Many chemicals are used in building materials to enhance product performance, particularly the performance of 'wet' materials such as adhesives, sealants, caulks, paints and coatings, among others. Some of these chemicals off-gas volatile organic compounds (VOC's), which are known to be among the most common sources of building 'loads'. These air-borne gasses are often solvent-based, and the most toxic can be carcinogenic, teratogenic or mutagenic, or they can be endocrine disrupters. Even in miniscule quantities, exposure to such chemicals can be extremely deleterious to human health. Opportunities exist in design and material specifications to minimize the presence of these and other toxicants. The elimination or reduction of toxic substances is a central objective of the sustainable goals of all World Trade Center projects. Heavy perfumes, air 'fresheners' and scented cleaners should also be avoided.

Moisture Intrusion

Moisture enters buildings in a number of ways, such as through the HVAC system and/or water infiltration through the building envelope. Broken or cracked pipes, leaks and excessive or uncontrolled humidity can also be the source of moisture on the inside of the weather barrier. Poor scheduling and management of deliveries can result in vulnerable, absorptive building materials being exposed to rain or damp conditions prior to being installed. Materials can also arrive with original manufacturer's protection and seals broken, or fail to be stored in accordance with manufacturer's instructions. Wet materials provide ideal conditions -- food, moisture and warmth – for the support of microbial growth, often resulting in building contamination. This condition can be the root cause of either 'Sick Building Syndrome' or, when the source of contamination can be specifically identified, 'Building Related Illness'.

Particulates

The third, common IAQ pollutant source is the result of the introduction of particulates, which have many sources, including the two outlined above. Particulates may be drawn in at air intakes from exterior sources such as vehicle combustion, neighboring flues, nearby industrial processes and ambient dust. Particulates are generated also by combustion equipment in the building and by tobacco smoke (ETS). They are emitted by typical office equipment. They are shed by many soft materials such as carpet, fabric and insulation, as well as by hard plastics such as those made with brominated fire retardants (PBDE's), which are used to make computer housings, printers, fax machines, copiers, etc. Particulates are also carried into the building on clothing and especially by footwear. In addition, some commonly used materials break down into fine particles during building renovation, such as crystalline silica (common in drywall compounds and grouts), which affects human lungs and respiratory systems.

When inadequate filtration media are used, particulates enter the air stream and circulate in the ambient air. (Note the requirement in IEQ-07 for MERV 13 filters, which remove 90% of contaminants and represent an effective, passive filtration system. They are required by LEED v2.1). Rigorous maintenance, with a regular replacement schedule for filtration media is necessary to avoid poor IAQ conditions and the reduction of filtration media performance.

The program for the WTC Site infrastructure includes significant space for the access and parking of buses, cars, and delivery trucks. These program components have the potential to introduce pollutants into the building and will require specific dedicated systems to isolate affected areas and minimize introduced toxins.

Relevant Issues

Ecological

Establishing a high level of indoor air quality at the time a building is occupied, and maintaining that level of air quality throughout the life of the building, are important strategies for the support of human health, well-being and comfort. Good indoor air quality has been demonstrated to be a significant, contributing factor to increased productivity. Studies undertaken by Judith Heerwagon, Ph.D, among others, indicate that occupant satisfaction, reduced absenteeism, minimization of errors and reduced 'churn' or turnover of staff, all result from enhanced indoor environments, and that of the several factors that contribute to such overall enhancement, high quality indoor air is a critical component.

Economic

A more rigorous approach to the design of the building, where every effort is made to address all three pollutant paths – building loads, moisture intrusion and particulates – having the potential to lead to future IAQ problems, involves a greater coordinated effort on the part of the design team. However, the learning curve will level out quickly, and no additional time or effort will be required to achieve high quality IAQ once the methodology and benefits are well understood. The return on this investment is both significant and fast, and achieved through worker productivity, reduced owner risk and the ability to attract and retain highly skilled employees. In addition, clean indoor air prolongs the life and efficiency of office equipment, contributing further to economic benefit.

The optimum manner in which to achieve a clean building interior with high quality indoor air is to eliminate contaminants at source, i. e., where possible avoid introducing materials that off-gas to the building interior, and design the building envelope and HVAC system to minimize any potential for moisture intrusion or the formation of unwanted moisture inside the weather barrier.. Provide adequate access for maintenance, the detection of moisture (mold, mildew, etc.) and potential future remediation of equipment that is not immediately visible. The introduction of greater quantities of conditioned, outside air than required by code (which provides only for minimum outside air), can flush-out the building on a continuous or intermittent basis, and will dilute building load concentrations. The old argument that the cost of increased energy to condition this additional outside air cannot justify the return on investment, and is particularly weak in the climate of New York City, which experiences many days in which the temperature and humidity are usable with little or no conditioning beyond filtration. In addition, technologies such as heat recovery can minimize the energy impact of increased outdoor air.

According to the Rocky Mountain Institute in their white paper 'Greening the Building and the Bottom Line' 1994, the national average cost in terms of salaries and benefits, per square foot, per annum, is $318.00, while the equivalent cost for all energy for the building per square foot, per annum, is $2.25. (Figures are averaged and have been up-dated to reflect 2004 conditions by Carnegie Mellon University's Center for Building Performance and Diagnostics). Since productivity increases for people working in green buildings have been demonstrated to range from a low of 2% to a high of 16%, in pure economic terms, it makes sense to invest in enhanced environmental conditions, particularly high quality air, rather than saving small amounts on the cost of energy. Commercial buildings, such as those envisaged for the World Trade Center site, will be built so that people can work: cost-effective measures that improve work output are a desirable outcome by any standard.

Neighborhood
Good quality indoor air leads to a healthier and more productive building community. IAQ is a localized issue, pertinent to each specific building rather than the community at large. However, striving to create a clean building environment creates conditions in which construction workers are exposed to fewer deleterious chemicals and substances, as well as offering a better environment for building occupants. This is a significant risk management strategy for the broader community of building owners, developers and realtors.

Methodology

- **Design Strategies**
  While all materials are of concern, those that cover large areas, such as floors, walls and ceilings should be the primary focus for sustainable choices, along with those that are known, generically, to have the ability to undermine indoor air quality. 'Wet' materials are among this latter group, such as paints, coatings, adhesives, sealants and caulks. Concealed areas, such as air return plenums and the inside of ducts behind grilles, which may be sealed or painted, should be addressed carefully. Design teams need to work with the referenced standards to make sure that all major materials with the potential to adversely affect IAQ meet the defined parameters

  At the beginning of the 21st century, there are many environmentally superior building materials available, and the designer's choice is rarely limited, unlike just a decade ago. In almost all areas, these materials are now also cost-competitive with their more toxic counterparts. Where there is a cost premium, it is usually defensible in terms of human well-being: because the resulting IAQ will often be of a higher quality with the use of environmentally benign materials, pay-back in terms of increased productivity is usually quickly experienced. Occasionally, a designer and an owner will agree on an environmentally preferable material that may have a cost premium over a material that is, for instance, a known carcinogen, simply on moral grounds.

  In order to minimize IAQ pollution, conduct a thorough review of the composition of all major materials and building products to determine the presence of toxicants.. Reduce the introduction of toxic substances into the indoor environment by eliminating chemicals known to cause serious health affects. The chemicals involved are frequently, but not always, carbon-based, volatile organic compounds, which are easily released to the warm indoor air from their host materials. Off-gassing of volatiles adversely affects indoor air quality (IAQ) and can result in compromised working conditions in the building, which include the potential for adverse health impacts, sick building syndrome (SBS), and reduced productivity. Most of these chemicals of concern are identified on manufacturer's Material Safety Data sheets (MSDs), which must be provided on request for all single component substances: i e –all caulks, adhesives, glues, paints, etc. For composite or multi-component products such as office seating (chairs) and office furniture systems, information on chemical emissions can be found through a review of the product's chamber test data – also available from manufacturers.

Other substances that are less volatile may not have an immediate impact on building occupants, but may have health impacts on workers during construction, or may generate toxic fumes in the case of a building fire, and/or may become airborne and dangerous to occupant health during future renovations. During the planning stages and in the materials review, include consideration of the longer-term impacts of all toxic components in building materials. Eliminate or reduce their introduction to the interior of the building wherever possible.

Once the team becomes familiar with environmentally benign materials, they will have established the basis of a library for future use. It is important to note that every material must be checked for continuing environmental quality on a regular basis and before each repeat use, which may be accomplished via a review of *current* technical literature and MSD sheets. This is a necessary precaution, as architects and designers have no control over manufacturers, and/or their right, often exercised, to change their product formulae without informing the public.

A poorly performing building envelop will allow weather conditions such as wind and wind-driven rain, for instance, to penetrate the skin and the weather barrier. Most curtain wall and building envelope systems do not perform as well as their manufacturer's claims, once installed. One option to guard against such conditions is to require random or selective testing of the building envelope as constructed. Damp conditions resulting from poorly designed and/or drained ventilation systems allow standing water to be present in ductwork, resulting in moisture 'carry through', especially in HVAC systems that depend on high velocity air delivery. Leaks allow moisture to penetrate into previously installed absorbent materials such as insulation, wallboard, ceiling tile, etc., while rain or water damaged materials and equipment offer ideal conditions for the support of microbial growth.

All of these situations support the growth of bio-contaminants - fungus, bacteria, and molds, which thrive in warm, often concealed interior spaces. Once airborne, these microbes are inhaled by building occupants. They are at the root of 'building related illness' (BRI) and are frequently the cause of serious infections such as Legionnaire's Disease. As previously noted, opportunities exist during the design of the building, especially the building envelope, to minimize the potential for moisture intrusion. Access to ductwork, pipes, valves and other vulnerable locations for observation and maintenance is an important environmental strategy for the long-term maintenance of high quality indoor air and protection of building materials. Care during construction to protect vulnerable materials and equipment from wet conditions is critically important and is the foundation of an effective process. Discard all absorptive materials that have become wet, or have been exposed to moisture prior to installation.

Particulates enter the building through multiple sources. Installation of good filtration systems such as passive MERV 13 filters, noted previously, is one way to control the introduction of particulates via air intakes. Another is to make sure the building is designed with permanent entryway systems at all major entrances. Permanent grille and recessed entryway systems help capture particulate matter that would otherwise enter the building on footwear.

Within the building, containing particulates generated by the operation of office equipment and maintenance activities at their sources, through direct exhaust of equipment rooms and janitorial closets to the outside, helps prevent their circulation in the ambient, interior air stream. Good maintenance, including the use of high quality, Carpet and Rug Institute (CRI) approved vacuum cleaners is key to capturing and removing particulate matter that does enter the building.

Human activities such as smoking (environmental tobacco smoke or ETS) contribute to the particulate load. Banned now in general areas of occupied buildings in New York City, smoking is restricted to 'smoking rooms', which must be designed with slab to slab partitions, dedicated exhausts to the exterior which afford no potential for the re-entrainment of contaminated air, and negative interior air pressure. It is important to note that this is a prerequisite of LEED™ V. 2.1 EQ Section and is required in order to receive any LEED™ V. 2.1 credits for [Indoor] Environmental Quality.

The following tables define the major factors that are of concern in maintaining high IAQ, including potential sources of pollutants, why they are of concern and basic control methodologies to reduce or eliminate their impact:

Exterior Factors

Item	Indoor Air Quality Issues	Control Options
Climate	Surface and air temperatures, humidity, wind, convective air currents. Wind driven moisture penetration	Design of thermal shell and glazing strategies, HVAC design
Outdoor air quality	Building location, intake air quality, intake air location, wind direction	Locate air intakes remote from sources of contamination, avoid re-entrainment of exhaust air, utilize high performance (MERV 13) filtration media
Infiltration of water	Uncontrolled moisture entry	Design and maintain waterproof construction

Base Building and Systems

Item	Indoor Air Quality Issues	Control Options
HVAC Systems	Fuel choice, minimum code compliant outside air ratios, moisture related bio-contamination, particulate contamination	Clean, renewable energy, building & HVAC system design to allow for high ratios of outside air (beyond code mandated amounts), design to minimize moisture carry through, high

		performance filtration media at air intakes, good maintenance
Finishes	VOC emissions during & after installation, toxic substances in building materials	Specify low or no VOC products, screen for specific toxic materials/chemicals that can become airborne.
Adhesives and sealants	Formaldehyde, xylene, toluene & other VOC emissions	Specify low-emission products in accordance with SCAQMD Rule 1168, current version.
Building insulation	Formaldehyde, Isocyanurate and other VOC emissions	Specify low-emission products. Avoid use of chemicals such as urea-formaldehyde that off-gas at room temperature.

Building Interior

Item	Indoor Air Quality Issues	Control Options
Absorbent finishes: Ceiling tile, wallboard, carpet, wall covering, insulation	Material 'sinks' absorb VOC's and/or moisture	Develop a construction sequencing plan where wet materials are first installed, then when dry, absorbent materials are installed. Keep all absorbent materials dry and clean during construction process
Composite wood products	Formaldehyde & VOC's	Avoid products bonded with urea-formaldehyde, select low-emission products and overlay adhesives
Laminates	VOC emissions from adhesives	Select low-emission adhesives. Avoid products bonded with urea-formaldehyde
Ceramic tile work	VOC emissions from adhesives/grout Crystalline Silica	Select low-emission materials Avoid use of products with added crystalline silica
Carpet	Long-term emissions of VOC's and plasticizers in backing materials and adhesives	Select low-emission carpet systems that meet or exceed the Green Label Plus and Green Label IAQ testing

		protocols established by the Carpet and Rug Institute.
Resilient flooring	Long-term emissions of VOC's and plasticizers in backing materials and adhesives	Select low-emission materials and adhesives; avoid use of chlorinated plastics, such as PVC.
Equipment & Appliances	VOC's, organics and low-level ozone from photocopiers & printers, combustion by-products from gas & fuel appliances	Dedicated ventilation of copier areas, exhaust flues to outside
Occupant activities	Cooking, laundry/dry cleaning, janitorial activities/smoking	Dedicated ventilation or building restrictions on indoor activities. Include separate sinks for all janitorial closets and chemical (cleaning material) mixing areas. Provide separate, isolated smoking rooms. Use environmentally benign cleaning/maintenance products.
Occupant bio-effluence	Odors; skin flakes, etc.	Good ventilation, high number of air changes per hour, use of environmentally benign building cleaning protocols
Cleaning Products	Volatile organic emissions from products, dust disturbance	Low-emission environmentally benign cleaning products, high-efficiency vacuum cleaners
Pest management	Pesticide residues, indoor and outdoor, animal droppings and dander, poisons	Develop an integrated pest management plan focused on environmentally benign treatments
Waste management	Recycling of waste on premises, potential for unsanitary conditions, pest problems	Develop a waste management plan, regular, high quality maintenance

Means and Methods

ASHRAE Standard 62-2001 includes minimum ventilation rates and lists indoor air quality levels that are considered to be the minimum to adequately protect human health and well-being. The building must be designed to meet these requirements to be in compliance with the code. Two procedures are described in ASHRAE 62-2001: The Ventilation Rate Procedure and the Indoor Air Quality Procedure. The Ventilation Rate Procedure is the preferred approach and is required for LEED Prerequisite 1: Minimum IAQ Performance (this procedure applies to mechanical ventilation systems only). Comply with all relevant sections of ASHRAE Standard 62-2001, which are important components of this standard and go beyond minimum ventilation and HVAC requirements. In addition, comply with Section 7, which addresses construction strategies. A sustainable building will strive to introduce more outside air than required by ASHRAE Standard 62-2001, which establishes *minimally* acceptable and therefore not *optimal,* rates for enhanced IAQ. The key therefore, is the ability for all mechanical systems to be able to use 100% outside air for distribution through the system at those times when enthalpic conditions are adequately cool and dry. In New York, the temperature ranges that are acceptable for this strategy fall between 55º and 85º F, when the relative humidity is between 30 and 60 % (NYGBTC)

In order to help meet the conditions of this chapter under the World Trade Center Guidelines, design teams must undertake the two separate, mandatory processes as required in IEQ-5 Construction IAQ Management Plan. These criteria are fully described in the EO-111/NYSGBTC, and are briefly outlined as follows:

1. NYSGBTC 638.7(d) (1): This section of the Tax Credit describes an Indoor Air Quality Testing procedure that must take place within 30 days after occupancy, and subsequently on an annual basis for five years. Testing must be done in accordance with the listed procedures and standards, and must meet the established IAQ limits for carbon dioxide, carbon monoxide, formaldehyde, particulate matter, radon (as noted) and TVOC's.

2. NYSGBTC 638.7(g) (1): In addition to the mandatory testing noted above, a one-week purge (seven days/twenty four hours) with air handlers operating at 100% outside air must be completed on every floor, prior to occupancy.

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

ASHRAE Standard 62-2001: "Ventilation for Acceptable Indoor Air Quality", utilizing the Ventilation Rate Procedure.

EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991

EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998

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Miller, E. Williard, et al. Indoor Pollution: A Reference Handbook. ABC-CLIO, 1998.

Moffat, Donald. Handbook of Indoor Air Quality Management. Prentice Hall, 1997.

Wabeke, Roger. Air Contaminants and Industrial Hygiene Ventilation: A Handbook of Practical Calculations, Problems, and Solutions. CRC Press & Lewis Publishers, 1998.

Objectives

The Indoor Air Quality (IAQ) Management Plan is designed to improve indoor air quality for the comfort and well-being of building occupants and to provide the means to address promptly any indoor air quality problems that may arise, thereby minimizing any potential impact to the building occupants. This Plan is distinct from the Construction IAQ Management Plan IEQ-5, which is more specifically designed to address air quality issues, which arise during construction. Prepare plan in accordance with the requirements of NYSGBTC 638.7(d)(1,2 and 3). Draft the plan in accordance with the EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991 and EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998.

Plan Components

I. **General Requirements**

A. Define Indoor Air Quality characteristics including; temperature range, humidity level, ratio of CFM/per person, air changes per hour, percentage of outside air vs. percentage of remixed air at any given time, and VOC, particulate and microbial contaminant load.
B. Designate an IAQ Manager for coordinating plan requirements and achieving plan objectives. This Authority must include on-going building inspections, and have immediate access to those who are in a position with to implement stop work orders for nonconformance with the Plan.
C. Establish means of communication and notification between all parties to prevent and resolve IAQ difficulties.
D. Outline local codes and city/state requirements.

II. **Base Profile**

At time of substantial completion of the building, establish an IAQ profile of the base building. This profile is to be based on the following.

A. Existing Records:
1. As built drawings
2. Commissioning documents.
3. Testing and Balancing Reports
4. Maintenance and Operations Manuals.
5. Material Safety Data Sheets for all major installed building materials and products
6. The Integrated Pest Management Plan (IPM)

B. After Occupancy

7. Records of complaints in regard to temperature and/or humidity
8. Records of complaints in regard to IAQ issue

C. Walkthrough.

1. Visual inspection of all installed HVAC equipment
2. Review locations of ventilation air delivery grilles
3. Review locations of air supply and return registers
4. Review independent (personal) airflow and temperature delivery locations and functioning of these systems
5. Review locations of all monitoring devices and confirmation of calibration against documentation provided
6. Visual inspection of isolation strategies at smoking rooms and rooms where high volume copying (over 40,000 pages/month) or janitorial activities, such as mixing of chemicals occurs
7. Check negative pressurization of rooms itemized in 6 above.
8. Check functionality and working order of independent exhaust systems associated with rooms itemized in 6 above.
9. Inspection of janitorial and maintenance spaces to ensure that each is supplied with separate sinks and waste plumbing.
10. Review entryway systems to confirm that all are equipped with grilles where appropriate, and/or permanent recessed mats to limit intrusion of mud, water and dirt.

Bring to the attention of the Owner and Architect any discrepancies found in the substantially completed building that are not in conformance with the drawings and planning intent for superior IAQ performance of the building, or that are not fully functional at this time.

III. Evaluation

A. Pre-Occupancy/Immediate Post-Occupancy IAQ Procedures and Evaluation.

At the time of ‘substantial’ completion, prior to the hand over of the building, the Architect shall undertake a one-week building flush-out using 100% outside air at a cool temperature. New filtration media shall be used during the flush-out. On completion of the flush-out, all filtration media shall be replaced with new MERV 13 filters, except for filters that only process outside air.

In addition, within the first 30 days of occupancy, conduct a baseline indoor air quality testing procedure that randomly selects sampling points for every 20,000 square feet, or for each contiguous floor area, whichever is smaller, to measure concentration levels for the chemical contaminants listed below. These tests must be conducted by a qualified IAQ expert or an industrial hygienist, and must conform to the conditions outlined in the NYSGBTC:

Chemical Contaminate	Maximum Concentration
Carbon Dioxide (CO_2)*	700 ppm above background
Carbon Monoxide	9 ppm for an 8 hour average maximum
	or 35 ppm for a 1 hour average maximum
Formaldehyde	50 parts per billion
Particulates (PM10) average	150 micrograms per cubic meter over a 24 hour
TVOC	200 micrograms/cubic meter
Radon	4 picocuries per liter

*NOTE: This (CO_2) measurement refers to a fully occupied building during testing. Where the maximum concentration limits of any of the noted concentrations are exceeded in any building area, a flush-out must be conducted for that area until and re-testing undertaken until the required IAQ levels are achieved.

B. Post-Occupancy Testing.

Executive Order 111, with reference to the NYSGBTC 638.7(d)(1,2 and 3), requires that the baseline IAQ test be repeated on an annual basis for the first five years of building occupancy. The test for radon may be excluded from these follow up tests, provided the indicated concentration level was not exceeded during the initial test.

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IAQ Performance IEQ-1-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Prerequisite 1: Minimum IAQ Performance)*
An Indoor Air Quality Management Plan is attached and meets the requirements of ASHRAE Standard 62-2001: "Ventilation for Acceptable Indoor Air Quality", utilizing the Ventilation Rate Procedure AND is prepared in accordance with the requirements of NYSGBTC 638.7(d)(1,2 and 3). The plan has been drafted in accordance with the EPA "Building Air Quality: A Guide for Building Owners and Facility Managers", 1991 and EPA and National Institute for Occupational Safety and Health, Building Air Quality Action Plan, 1998.

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Environmental Quality Prerequisite 2: Environmental Tobacco Smoke (ETS) Control)*
Documentation is attached, which clearly demonstrates that an adequate number of 'smoking rooms' has been provided within the project to prevent the potential of Environmental Tobacco Smoke (ETS) from circulating in the ambient indoor air, as required by New York City law. All smoking rooms are fully isolated and have been designed with impermeable, slab-to-slab partitions, separate, dedicated exhaust fans to the exterior, designed to prevent the re-entrainment of smoke, and a negative pressure differential of at least 7PA (0.03 inches of water gauge) to the surrounding area.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Daylight and Views IEQ-2

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Provide building occupants with connections to the outdoors through the introduction of daylight into habitually occupied areas of the building. Provide building occupants with views via direct line of sight to the outdoors from regularly occupied spaces when possible.

Action: Towers: Provide a 2% minimum daylighting factor to 75% of regularly occupied tenant spaces. Build an exemplar tenant office fit-out (5,000 SF) to demonstrate optimum daylight access, louvers and glare controls, and ceiling geometries intended to optimize daylighting strategies. Quantify performance of integrated curtain wall and tenant fit-out with proposed savings

Retail: Seek to maximize daylight penetration to concourse areas and below grade retail areas. Provide views to the outdoors from concourse areas to assist users in wayfinding and orientation.

Related Guidelines: SEQ-11, EEQ-1, EEQ-2, EEQ-8, IEQ-10, and IEQ-12

Potential LEED™ 2.1 Credits: 2 possible with EQ cr. 8.1 & 8.2. (See Submittal Template)

Introduction/Context

Daylight has long been recognized for its beneficial effect on human beings. Individuals isolated from natural light become disoriented and listless. Workplaces without adequate daylight, it is now known, result in less than optimum occupant productivity. Access to natural light, even ‘borrowed’ light, provides a sense of time of day and season of the year, resonating within the sub-conscious human mind, reinforcing the circadian rhythm and contributing a sense of well-being.

Studies confirm that access to daylight is a vital component of human well-being, supporting mental health, productivity, and a sense of connectivity to nature. The human mind acknowledges this, both consciously and unconsciously. People consciously choose to sit at the restaurant table near the window; the corner office, with windows in two directions, is always the prized location. Recent studies have found that workers with good access to daylight have a more positive attitude and work experience. They also tend to rate job satisfaction higher than those who do not, as demonstrated in the new Herman Miller, Inc. facility in Holland, Michigan, studied by Heerwagen and Wise in 1998. In another study by Roger Ulrich and Rachel Kaplan, it was shown that having access to a window and outdoor views while working reduced stress significantly, and contributed to an enhanced state of mind. For these, as well as the economic reasons noted below, all World Trade Center site buildings should be designed to maximize day-lighting, and to take full advantage of the multiple human and conservation benefits offered through this sustainable strategy.

Utilizing naturally day-lit spaces has the potential to improve building economics in several ways. Reducing the need for electric lighting in all areas at all times saves energy, and therefore money, while also reducing pollution. A reduction in the electric lighting load diminishes heat build-up within the building, creating conditions where less air conditioning is needed to satisfy the cooling requirements. Also, as shown by the studies above, people are more content and healthier in day-lit spaces. Productivity goes up, and absenteeism goes down. When VeriFone, a California-based technology company, renovated one of its basic administrative and shipping centers in Costa Mesa, to include day-lit spaces for all workers, the company saw a 60% savings in energy costs, a 5% increase in productivity and a 45% drop in absenteeism when measured against a similar facility. Such savings have a significant effect on the bottom line of any business.

In recent times, public transportation centers and retail concourses have not focused on natural lighting as a design feature -- concern for the management of glare and solar gain was minimal, while views to the outdoors were not even considered. With the new understanding of the importance of this element, more and more, day-lighting is being utilized as a major design element in new transportation facilities and other large public spaces. For example, at the Interface Flon Railway and Bus Station in Lausanne, Switzerland, the ground surface is peeled back to allow a view corridor to the outside, as well as natural daylight to flood in, penetrating down to the covered rail platform below. Also, many of the new rail stations along London's new Jubilee Line purposefully have large areas of glass to allow daylight to penetrate several levels underground.

Relevant Issues

Ecological

Daylight is a form of free energy. Lighting accounts for 20%-25% of electricity consumption nationwide (and upwards of 30% of the energy load in corporate offices), so maximizing the use of natural light can save a significant amount of electricity. Recent examples of sustainable building -- such as The Natural Resources Defense Council's Headquarters New York, NY (1988), and the Development Resource Center, Chattanooga, TN (2002) -- have demonstrated that incorporating multiple, deep day-lighting techniques into a building, save more than 60% of lighting energy. Saving electricity is an important way to conserve natural resources and reduce the air and water pollution typically associated with the generation of electricity at power plants. Therefore, lessening the lighting load by taking advantage of a free resource not only saves on costs, but helps to mitigate such ecological problems as acid rain, global warming, and the proliferation of nuclear waste. Less demand for electricity generation supports the reliability of the regional power supply with peak demand reduction, while also contributing to improved local air and water quality.

Economic

Any incremental cost to initial project costs associated with optimizing day-lighting through integrating sustainable measures will be quickly offset by readily quantifiable benefits. Day-lighting strategies save money on electricity expenses, especially when used in conjunction with occupancy sensors and photometric lighting controls, which ensure that lights turn off when not required and/or when daylight levels are adequate. Since high levels of daylight are available and may be tapped during hot summer afternoons when electrical usage in commercial buildings for air conditioning is typically at peak demand, benefits may accrue both through reduced consumption and by avoiding the higher peak demand charges typically levied by power utilities. When natural light is introduced in a controlled manner in conjunction with other sustainable strategies, such as smart glazing and appropriate louvers and/or window shades designed to prevent the build up of solar heat gain, daylighting also saves energy and money, as well as reducing the pollution related to building cooling.

Some types of electric lighting, such as incandescent sources produce significant heat themselves, which increases the cooling load. In many installations, this may be avoidable with reduced use of high heat generating lamps through increased use of daylighting. Besides these direct energy savings, daylighting may also contribute to a reduction in employee labor costs. Optimized access to day-lighting minimizes lamp usage and therefore replacement turn-around time and associated maintenance costs. Studies have shown that workers in daylit offices with views to the outdoors tend to be more productive, have better performance in tasks that require visual acuity, and are less prone to absenteeism. All of these factors translate into greater profits for business owners.

Neighborhood

Day-lit spaces tend to produce more satisfied occupants. This holds true for a variety of situations from typical office occupancies, to transportation centers, restaurants and retail establishments. Studies have shown positive health benefits including better sleep cycles, less instances of depression, and fewer people with symptoms of sick building syndrome (SBS) as a result of spending longer hours in day-lit interior spaces. Exposure to natural light and views has also been linked to greater and more positive social interaction, increased relaxation, and faster recovery from illness. The integration of daylight into building projects can be used as an aid in ‘wayfinding’. Light can be modulated to direct movement and make people feel more secure and comfortable.

Methodology

Design Strategies

Orient buildings on their site to maximize daylight potentials. Incorporate glazing in quantities and locations to maximize daylight transmission while minimizing energy loads. Plan the building form in a manner that maximizes the ratio of perimeter space to internal space and make efforts to incorporate outdoor spaces such as courtyards into the building design, especially where a large floor-plate is contemplated. Use design strategies and technologies to maximize daylight penetration into occupied spaces of the building. For The Towers provide at least a 2% daylighting factor to 75% of regularly occupied spaces. This will satisfy the requirements for one LEED® Credit. To maximize energy saving potential, coordinate the control of electrical lighting systems with the amount of daylight available. To set a precedent for tenants, provide a sample tenant fit-out that illustrates ideal daylighting goals and methods by which to achieve them. Quantify the proposed savings that a tenant can expect if they follow this exemplar. Bring daylight into spaces below grade and use it in conjunction with wayfinding cues. Design the concourse areas to have a visual connection to the outside to further support wayfinding and orientation. A second LEED Credit will be achievable if a direct line of sight to vision glazing can be provided for building occupants in 90% of all regularly occupied spaces. Studies in recent years have indicated the importance of views from interior spaces, the significance of which is only now beginning to be realized.

Means and Methods
Both physical and computer modeling techniques can be used to design a building for daylighting. Daylighting software can accurately simulate lighting conditions inside a building and allow designers to study variables, such as building form and orientation, aperture location and size, and elements to help bounce daylight inward. Based on knowledge gained from such lighting studies, designers can follow a series of strategies to produce a successfully daylit space. To orient a building to capitalize on daylight potentials, it is essential to have a thorough understanding of the characteristics and movement of the sun across a site, as it varies throughout the day and year. It is also important to consider the impact of shading from existing and future buildings as this too affects the quality and of daylighting and its access.

Formal strategies to maximize daylighting include such measures as keeping the building floor plates narrow, and/or including open courtyards or sky-lit atria in the design. The inclusion of a sufficient number of apertures such as windows, clerestories, and skylights, as well as their careful placement, is critical. The interior layout of the building will benefit from an open plan or interior glazing at partitions to allow the light to pass, as borrowed light, deeper in towards the building core.

The sectional geometry of a building can have a major influence on its ability to be effectively daylit. Ceilings that slope and are light in color can help draw daylight inward. Elements such as interior light shelves, exterior fins, louvers, and adjustable blinds can also bounce light deep into a space. Light reflective colors on large surfaces such as walls, ceilings and floors, help to distribute light deeper into the building. Furniture that is set back from the window wall, leaving an outboard corridor, allows for uninterrupted light access, while low partitions at furniture systems further enhance this strategy.

Other daylight transport technologies can be use to bring natural light into a building. Some of these technologies are passive, like light pipes that use mirrors to bounce light multiple times until it reaches the building's interior. Other options include active technologies like the Himawari system which, when located on a building's roof, actually tracks the sun and transports natural light into the building through small fiberoptic tubes.

When incorporating large expanses of glazing into a building to maximize daylighting potentials it is important to avoid energy liabilities. Advanced glazing with high R-values and low emissivity coatings may be used to minimize heat loss during the heating season. These new smart glazing characteristics, along with the use of special reflective films and coatings, can help control excessive solar gain during the cooling season, while also mitigating uncomfortable glare.

Control technologies are essential to any daylighting system. Photosensors integrated with the building management system can be used to coordinate between daylight and electrical lighting. Daylighting will produce energy savings only if the electric lights are dimmed or turned off when not needed.

Case Studies

Genzyme Center, Cambridge, MA

This office of a biotechnology company, a LEED Platinum building, was designed to incorporate a number of daylighting strategies both fundamental and novel. The building has an open floor plan to allow exterior daylighting to penetrate to the interior. A large atrium at the building's center brings daylight into the innermost spaces. Sweeping views of the exterior surroundings are visible from virtually all areas of the building. Photo and occupancy sensors detect lighting conditions and dim the overhead electric lights as more daylight enters the building. These controls are expected to reduce lighting energy use in the building by around 45%. An additional system was designed to help bring greater amounts of natural light further into the building. A series of roof-mounted heliostats track the sun's movement in the sky and bounce light to a series of fixed mirrors that in turn reflect the light to prismatic louvers at the top of the atrium. The louvers, which also move with the sun, reflect glaring direct sunlight back to the mirrors but allow only diffuse light to enter the atrium. The diffuse light is reflected to the building's floors by an innovative system of hanging prismatic mobiles, reflective panels, and a reflective light wall on the inner surface of the atrium. Glazed walls on the building's perimeter are equipped with horizontal, reflective, motorized blinds that direct light up to reflective ceiling panels that bounce it deep into the building's core.

California State Automobile Association (CSAA) District Office, Antioch, CA

The CSAA felt that the daylighting design of this prototype building was so successful that they adopted the design as a day-lighting standard for their future offices, nationwide. The building's ceilings are sloped downward from its center to its perimeter to help distribute light uniformly. Triple-pane, low-glare skylights introduce daylight throughout the office. Skylights are placed in wells that are splayed at a 45-degree angle to provide optimal lighting quality and dispersion. Louvers incorporated at the top of the skylight wells are controlled by photosensors and continuously modulate the amount of light entering the building to maintain a glare-free illumination level of around 70 footcandles. The electric lighting system uses highly efficient T-8 fluorescent lamps with dimmable electronic ballasts. Controlled by data from photosensors, these ballasts provide continuously adaptable dimming that can reduce light output from 100%down to 20%, and power requirements from 100% to 40% as daylight levels increase. When illumination levels from daylight exceed 60 footcandles, the electric lighting shuts off. Task lighting with energy efficient fluorescent lamps and electronic ballasts is located at workstations to provide additional light in specific areas and for light-sensitive work or highly detailed tasks. High R-Value glazing with a spectrally sensitive coating provides views to the outside world without creating a major energy liability. Fixed-pitched perforated window blinds control glare without eliminating visibility.

Reference

Definitions

Definitions have not been provided for this Guideline.

Standards

Standards have not been provided for this Guideline.

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Daylight and Views IEQ-2-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		◉ Ⓔ	◉ Ⓔ	◉	◉

Towers:

☐ **Required Component:** *(This will satisfy LEED™ 2.1 Indoor Environmental Quality Credit 8.1: Daylight and Views – Daylight 75% of Spaces)*
75% of regularly occupied tenant spaces have a daylight factor of at least 2%. A 5,000 SF tenant office fit-out has been built to demonstrate optimum daylight access, use of louvers and glare controls, and ceiling geometries intended to optimize daylighting strategies. The performance of the integrated curtain wall and tenant fit-out has been quantified with respect to anticipated/proposed savings.

☐ **Optional Component:** *(To satisfy LEED™ 2.1 Indoor Environmental Quality Credit 8.2: Daylight and Views – Views for 90% of Spaces)*
Direct line of sight to vision glazing has been provided for building occupants in 90% of all regularly occupied spaces.

Retail:

☐ **Required Component:**
Daylight penetration to concourse areas and below grade retail areas has been maximized, where possible. Views to the outdoors have been provided from concourse areas to assist users in way-finding and orientation.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Air Quality Monitoring IEQ-3

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To retain high indoor air quality standards by establishing monitoring protocols to assist in maintaining appropriate ventilation rates for the comfort and well-being of building occupants.

Action: Indoor air quality must be tested annually and must meet minimum criteria for five years in accordance with minimum requirements of NY State EO-111 reference to NYSGBTC 638.7(d)(1). Once radon measurements are found to be satisfactory, subsequent testing for this contaminant is not required. Where concentration levels of noted contaminants exceed the established parameters in any specific area during this 5-year period, seek to locate and remediate/ eliminate contaminants, then flush out area with 100% outside air for a minimum of one week and retest until a satisfactory result is achieved.

Consideration should be given to a permanent indoor air quality monitoring system with centralized controls that provides feedback on ventilation performance and contaminant concentrations based on a combined carbon monoxide, carbon dioxide and volatile organic compound monitor.

Related Guidelines: SEQ-5, EEQ-6, IEQ-1, IEQ-4, IEQ-5, IEQ-6, IEQ-7, IEQ-9

Potential LEED™ 2.1 Credit: 1 possible with EQc1. (See Submittal Template)

Introduction/Context

In the USA, ventilation standards for mechanically ventilated buildings are established, maintained and up-graded on an on-going basis by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). ASHRAE, an independent organization, establishes standards that define the *minimum* amount of outside air that must be delivered in cubic feet per minute (cfm) to a specific building type such as a corporate office, or area of activity within that building, such as a gym, in order to achieve code compliance. This air, together with the building make-up air, needs to be monitored to ensure that its quality is consistently safe and is maintained at optimum levels for occupant comfort and well-being.

Historically, one of the most common methods of assessing the quality of indoor air was to measure CO_2 levels within the building against a pre-determined, outside air baseline. All outside air carries an ambient load of carbon dioxide (CO_2), which mixes with the carbon dioxide generated by the occupants' respiratory systems within the building. In order to provide a relevant monitoring methodology, a table that addresses occupant activity differentials, acceptable CO_2 levels, and therefore acceptable IAQ, is provided in ASHRAE Standard 62-2001 Appendix C. For typical office space, this level has been established at, or below, 530 ppm above outside ambient air CO_2 levels. Recently, monitoring CO_2 levels as the only indicator of air quality has begun to be challenged by more advanced thinking among building professionals and through new approaches being developed for green buildings.

Relevant Issues

Ecological

Ventilation rates in excess of the minimum standards, along with good filtration, provide better indoor air quality over the long term, and have been demonstrated to contribute to increased productivity and occupant satisfaction. Reduced absenteeism, less building–generated malaise and sick building syndrome (SBS) among workers can contribute to greatly increased profitability. High quality indoor air can best be maintained in mechanically ventilated buildings by the use of a monitoring system that addresses a broader spectrum of factors known to have the potential to adversely affect IAQ, and subsequently human well-being.

EO-111 and the NYSGBTC require annual monitoring of a series of air-borne contaminants for the first five years after occupancy.,This process is intended to establish and reconfirm that the World Trade Center buildings are maintaining appropriately high indoor air quality. Licensed industrial hygienists or IAQ professional engineers will undertake this work. However, this credit addresses a permanent monitoring system that will be used on a day-by-day basis by building personnel (the manager and/or the building engineer) to analyze, modify if necessary, and maintain air quality in the building, to help ensure a comfortable environment for all building occupants.

Economic

Increased ratios of outside air that are drawn from clean sources and are well filtered reduce the potential for the build-up and concentration of contaminants entering the building via the HVAC system, or generated within the building by material loads, systems, tenant activities and the occupants themselves. The argument concerning the cost of increased energy necessary to condition this additional outside air vs. return on investment in terms of human well-being and productivity is addressed in IEQ-1 IAQ Performance.

A comprehensive, permanently installed monitoring system that tracks pollutants in both densely occupied spaces such as conference rooms, cafeterias, etc. as well as typical office occupancies, adds cost to the construction of the building. However, the cost of monitoring equipment and a direct digital control (DDC) system (including installation and maintenance) that provides performance feedback to building personnel, is likely to be quickly off-set by pay-backs in worker satisfaction, reduced complaints about subsequent maintenance, and increased productivity. There is also an energy benefit as conference rooms, cafeterias, etc. are not typically used continuously.

Neighborhood

In these times of greater awareness and sensitivity to human well-being and comfort, with all associated benefits, it is important to provide optimum conditions for a healthy environment. A comprehensive IAQ monitoring program can contribute to a healthy environment and increased personnel comfort, thereby reducing absenteeism and medical costs, as well as increasing the life of the HVAC system. It is an investment in the quality of the building and the buildings' greatest assets, the workforce that it houses.

Methodology

Design Strategies

The design and inclusion of a comprehensive air quality monitoring system is considered to be both appropriate and well within the technological scope of the Class A office buildings designated for the World Trade Center site. This investment is well worth it as it will increase the life as the HVAC system. It is important to maintain CO_2 monitoring for all densely occupied spaces and spaces that have fluctuating populations, such as conference and meeting rooms, auditoria, places of assembly, training rooms, classrooms, break-rooms and cafeterias. Locate all CO_2 sensors within the breathing zone of each space. In addition, an outdoor airflow monitoring system may be considered to address other spaces which are subject to different contaminant releases in the building.

Design a CO_2 / outdoor airflow monitoring system which is connected to a DDC system capable of both trend and alarm functions and which allows for the remote monitoring of IAQ. A centralized DDC system that indicates when ventilation rates are not being maintained at optimum levels and/or senses an unhealthy build-up of air-borne contaminants, allowing for immediate corrective action, is a preferred methodology. The up-dated ASHRAE Standard 62 ventilation rate calculation method indicates a rate for the dilution of bio-effluents, as well as a rate for the dilution of other typical building contaminants. Refer to Addendum 62n of the Standard.

Means and Methods

Layout the location of sampling points and types of equipment intended for use in monitoring ventilation performance throughout the building. Make sure that sensors are calibrated to perform with accuracy. This must be done at the factory – CO_2 sensors must be certified to have an accuracy of 75 ppm or higher, calibrated at start-up. They must be certified to require recalibration no more frequently than once every five years. Both CO_2 and outdoor airflow monitors should be equipped with building automation system alarms that indicate when the outdoor airflow rate drops below fifteen (15%) percent of the minimum rate required by ASHRAE standard 62.1 for any reason.

In order to help meet the conditions of this chapter under the World Trade Center Guidelines, design teams will have to undertake the two separate, mandatory processes as required in IEQ-5 Construction IAQ Management Plan immediately following occupancy of the building. These criteria are fully described in the EO-111/NYSGBTC, and are briefly outlined as follows:

WTC Guidelines (Including EO 111 & NYSGBTC Requirements):

1. NYSGBTC 638.7(d) (1): This section of the Tax Credit describes an Indoor Air Quality Testing procedure that is intended to take place within 30 days after occupancy, and subsequently on an annual basis for five years. Testing must be done in accordance with the listed procedures and standards, and must meet the established IAQ limits for carbon dioxide, carbon monoxide, formaldehyde, particulate matter, radon (as noted) and TVOCs.

2. NYSGBTC 638.7(g) (1): In addition to the mandatory testing noted above, a one-week purge (seven days/twenty four hours) with air handlers operating at 100% outside air must be completed on every floor, prior to occupancy.

Case Studies

Energy Resource Center, Downey California
The Southern California Gas Company commissioned the design of this building to serve as a working model of their commitment to environmental stewardship. As part of the requirements that the ERC offer a healthy working environment for the company's employees, a permanent monitoring system was included to track indoor air quality, and to take corrective action when pre-set levels of contaminants are exceeded. In the main hall of the building, sensors monitor carbon dioxide levels and signal the air handling system to adjust the amount of fresh air at the intake to flush-out excess CO_2 and other contaminants. To further insure a high level of indoor air quality, the buildings' standard maintenance program includes a rigorous schedule for the inspection, cleaning and/or replacement of system components such as cooling coils, drain pans, and air filters. (Southern California 2005)

Pharmacia Building Q, Skokie, Illinois
This LEED V. 1.0 Gold rated building is home to a chemistry laboratory focused on research in metabolism, toxicology, medicinal chemistry, genomics, and process development targeted toward the treatment of arthritis and cardiovascular diseases. Because of the nature of its laboratory program, and in order to keep occupants safe, indoor air quality was a major design concern. The HVAC system supplies 100% outside air that only passes through the facility once and then is directly exhausted to the outside. Although this high air change rate virtually eliminates the buildup of pollutants, a control system is used to continuously monitor the air for carbon monoxide, carbon dioxide, total volatile organic compounds, and particulate levels. The building also has a non-toxic cleaning policy that prohibits the use of chemicals known, or suspected, to have an adverse effect on human beings. The cleaning materials and maintenance program mandates that all products used in the building are low in toxicity, free of phosphates, contain no ethers, and are biodegradable. (USGBC 2004)

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

ASHRAE Standard 62-2001 (Appendix C).

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Air Quality Monitoring IEQ-3-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEEDTM Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Prerequisite 1: Minimum IAQ Performance)*
This certifies that:

- Indoor air quality (IAQ) testing was completed within thirty (30) days of the initial occupancy of the building and will be undertaken annually for the next four years. Measures will be taken to ensure that IAQ continuously meets the minimum criteria for indoor air quality requirements as established by NY State EO-111 reference to NYSGBTC 638.7(d)(1).
- Radon measurements were taken: if found to be unsatisfactory (levels above 4 picocuries per liter) the owner has taken steps to have the condition mitigated.
- Measurements indicate radon concentrations in the building are at, or are less than, the 4 picocuries per liter level established by the approved test protocol.
- Where concentration levels of noted IAQ contaminants exceed the established parameters in any specific area during the initial 5 year period, actions will be taken to locate and remediate/eliminate contaminants, then flush out area with 100% outside air for a minimum of one week and retest until a satisfactory result is achieved.
- A permanent indoor air quality monitoring system with centralized controls that provides feedback on ventilation performance and contaminant concentrations based on a combined carbon monoxide, carbon dioxide and volatile organic compound monitor has been installed

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 1: Carbon Dioxide Monitoring)*
This certifies that a permanent carbon dioxide monitoring system has been installed and has centralized controls that provides feedback on ventilation performance and contaminant concentrations. A summary of the system, its design, and controls has been provided.

Name	Signature
Company	Role in Project
Date	

Ventilation Air Quality IEQ-4

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide outside air to all occupied spaces in the building to support the comfort and well-being of building occupants and as an energy conservation measure.

Action: Demonstrate that the requirements of Section 5, 'Best Practices for Maintaining IEQ' of the International Performance Measurement & Verification Protocol, Volume II 'Concepts and Practices for Improved Indoor Environmental Quality', March 2002 have been met. Provide capability for system default to 100% outside air at all times where practicable and in balance with energy conservation.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-6, IEQ-1, IEQ-3, IEQ-5, IEQ-6, IEQ-8, IEQ-10

Introduction/Context

Good indoor air quality has a profound effect on both the morale and productivity of building occupants. The quality of indoor air is influenced by a large number of factors including the generation of indoor pollutants (see IEQ-07), the treatment of recirculated air, the operation of the HVAC System, control of moisture within the building, housekeeping procedures, and, most importantly, the quality and quantity of ventilation air brought into the building. Provision of high quality ventilation air requires control not only of the source of the ventilation, but also its treatment, handling, delivery and control.

Many indoor air quality experts, including industrial hygienists and mechanical engineers, focus on the effects of indoor air quality on human health and productivity. Studies by such well known experts in the field – William Fisk, P. O. Fanger and David P. Wyon, among others, indicate that current code minimums are not optimum for human well-being and that increased levels of outside air are beneficial to all aspects of human endeavor. It should be noted that most of these studies were written prior to the introduction of the up-dated ASHRAE Standard 62-2001, which actually *reduces* mandated amounts of outdoor air from the previous ASHRAE Standard 62-1999. This further justifies all efforts to increase the amount of ventilation, or outdoor, air in a sustainable building.

According to P. Ole Fanger in his article written in 2000: 'Indoor Air Quality in the 21st Century: Search for Excellence ', "Field studies demonstrate that there are substantial numbers of dissatisfied people in many buildings, among them those suffering from sick building syndrome (SBS) symptoms, even though existing standards and guidelines are met. The reason is that the requirements specified in these standards are rather low, allowing a substantial group of people to become dissatisfied and to be adversely affected. A paradigm shift from rather mediocre to excellent indoor environments is foreseen in the 21st century". Since this article was written, code mandated ventilation air rates in the US have been lowered!

Relevant Issues

Ecological

Well-documented studies clearly indicate the positive qualities in the relationship between increased levels of highly filtered, conditioned outdoor (ventilation) air and human well-being. While ASHRAE 62-2001 sets a standard for minimum amounts of outdoor air in buildings, a sustainable project, which looks to enhance the quality of the indoor environment, will endeavor to increase those amounts in order to reduce the pollutant load and support known productivity benefits and human comfort factors found in response to such a strategy.

Economic

Indoor air pollution is one of the five most urgent environmental problems facing the United States, according to the EPA. Numerous studies have demonstrated that improved indoor air quality increases productivity, reduces absenteeism, improves employee health and lessens the potential for litigation. A 1997 joint study between the U.S. Department of Energy and Lawrence Berkley National Laboratory estimated total costs to the U.S. economy of poor indoor air quality range as high as $168 billion/year.

There is an argument, frequently proffered by experts in energy conservation that it is 'too expensive' in terms of energy costs to introduce outdoor air in greater amounts than mandated by code. It is true to say that this additional air must indeed be treated – conditioned, dehumidified, filtered, etc. -- which does use some energy. However, use of heat recovery systems, among other technologies, can offset the energy impact of increased ventilation. Further, when weighed against the impact of human well-being, increased productivity and personal job satisfaction, this argument loses much of its validity in terms of economic value. The Rocky Mountain Institute's study of staff costs versus various facility costs, including energy, for a typical office building indicates that for every $2.25 spent as the annual cost of energy per sq. ft., $318.00* are spent as the annual cost of salaries and benefits for staff, per sq. ft. It therefore follows that maintaining a desirable interior environment with high quality indoor air that meets the comfort criteria of the office staff, makes enormous economic sense.

***Note:** Figures are based on national averages and were updated by Carnegie Mellon University's Center for Building Performance and Diagnostics, 2004.*

Neighborhood

Ventilation air quality is an interior building issue and does not have a significant impact on the neighborhood. Avoiding health issues that could arise from poor quality indoor air lowers health insurance premiums for businesses, which benefits both employer and employee.

Methodology

Design Strategies

The International Performance Measurement and Verification Protocol, Chapter 5: 'Best Practices for Maintaining Indoor Environmental Quality' outlines 6 widely accepted best practice strategies, as follows:

1. Limit pollutant emissions from indoor sources
2. Assure adequate quality of intake air
3. Maintain minimum ventilation rates
4. Ensure proper filtering of recirculating indoor air
5. Institute a regular preventive maintenance schedule for the HVAC System
6. Integrate IEQ measures into a whole building approach

Measures 2 and 3 relate directly to the quality, quantity and control of outside ventilation air. The following strategies help insure that these practices will be observed:

1. Acquire outside ventilation air from locations remote from pollution sources.
2. Treat outside ventilation air to remove pollutants.
3. Avoid pollution of ventilation air from off-gassing or particulate shedding materials within air-handling systems.
4. Avoid creation of high relative humidity environments that will foster biological growth within ventilation air supply system.
5. Monitor airflow volume to insure adequate ventilation air provision to all locations of the building.

Means and Methods
An increased amount of outside air over the current code, ASHRAE 62-2001, has been demonstrated to contribute to productivity and human well-being and is one of the distinguishing characteristics of a sustainable building. In addition, all outside air inlets need to be located as high as possible and away from vehicle exhausts, building exhausts, cooling towers, flues, and other potential pollution sources. Avoid the introduction of pollution streams from adjacent buildings. The use of higher efficiency particulate filtration at ventilation air intake avoids the introduction of particulates into the ventilation air distribution system.

Reduce building loads, especially solvent-based, butyl sealants for ductwork and components of the air handling system. Utilize silicone sealants for air-handling applications. Only non-fibrous duct liner or fibrous duct liner encased with a non-porous anti-microbial coating should be used. The coating must not adversely affect the surface flammability, and must maintain a flame spread/smoke of less than 25/50 when tested by ASTM E-84. Such coatings must be made without the use of halogen-based flame retardants, as these chemicals will generate toxic gases when heated to extreme temperatures (as in the case of a building fire). Coatings should show a growth reading of zero by ASTM G-21, and should show greater than 99% effectiveness in the reduction of a mixed bacterial inoculum by ASTM G-22, and should also have demonstrated fungicidal action.

Dehumidify ventilation air upon introducing it into the building. Long distribution runs of untreated outside air through conditioned space can cool the conveyed ventilation air, thus raising its relative humidity to levels sufficient to sustain fungal growth.

Install systems with positive dynamic control of outside air ventilation rates, rather than systems that rely on a static outside air damper. Utilize control systems that consider the outside air fraction of the circulated, conditioned supply air when setting the minimum airflow rate for zones in variable air volume systems. Zones operating at a lower part load when the air handling system is operating near design capacity may receive less than minimum outside air ventilation unless the control system raises the minimum airflow rate in response to outside air fraction.

Utilize carbon dioxide sensing to establish outside air ventilation rates for critical spaces within the building. Select diffusers and diffusion strategies with ventilation effectiveness to insure proper delivery of air to spaces and to avoid stagnant areas within occupied spaces.

Case Studies

<u>4 Times Square, New York, NY</u>
Tenants in this residential tower are provided with ventilation that surpasses the relevant codes Outside air is supplied to the building at 0.20 cfm/ft^2 and occupants can adjust their own supply to as much as 0.50 cfm/ft^2 if they desire. If the need for an emergency flush-out arises, the HVAC system has the capacity to perform a complete flush-out using 100% outside air on any three floors of the building at the same time. All fresh air for this building is drawn in high above the street beyond the reaches of traffic emissions. Air is monitored centrally and ongoing periodic air quality testing for carbon dioxide and carbon monoxide helps ensure that tenants are breathing high quality air. The skin of the building was designed to allow up to 30% relative humidly without the problem of condensation forming on windows even in the winter months.

<u>Cambria Office Building Pennsylvania DEP Ebensburg PA</u>
Specifications for this project included an IAQ Management Plan for construction that mandated protection and/or cleaning of ventilation systems prior to occupancy and insured reduced levels of construction contaminants in the building by requiring a 2-week flush out with 100% outside air and the changing of filter media. The building is equipped with permanently installed indoor air quality monitoring devices for measuring humidity, temperature, CO_2 levels, and VOC's. Floor-mounted air distribution diffusers provide 100% ventilation efficiency. The diffusers also provide individuals with the ability to adjust their own thermal comfort. Each occupant can control and vary the amount of air delivered to their workspace. Operable windows, for natural ventilation, also exist throughout the building.

<u>The Plaza at PPL Center, Allentown ,PA</u>
Sensors in every room monitor carbon dioxide levels within the Plaza, ensuring that outside air is supplied directly to each building area as needed. This surpasses current best-practices standards for ventilation performance. An enthalpy recovery wheel is supplemented by humidification control to help promote thermal comfort all year through. Interior finish materials including

paints, carpets, adhesives, sealants, and composite wood paneling were selected for low emission of VOCs, urea-formaldehyde, and other contaminants, and all building spaces were flushed-out with 100% outdoor air for two weeks before occupancy.

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Standards

International Performance Measurement and Verification Protocol. Concepts and Practices for Improved Indoor Environmental Quality. Volume II. IPMVP, 2002.

ASHRAE Standard 62-2001 -- Ventilation for Acceptable Indoor Air Quality (ANSI Approved)

ASHRAE 129 Air Change Effectiveness

ASTM D 6245 Standard Guide for Using Indoor Carbon Dioxide Concentrations to Evaluate Indoor Air Quality and Ventilation

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Building Air Quality: A Guide for Building Owners and Facility Managers; Superintendent of Documents; Pittsburgh, PA 15250-7954; S/N 055-000-00390-4;

City of New York. High Performance Building Guidelines. City of New York, Department of Design and Construction, 1999.

Fisk, William J. and Rosenfeld, Arthur H.; Estimates of Improved Productivity and Health From Better Indoor Environments. Lawrence Berkley National Lab & U.S. Dept. of Energy: Berkeley, CA, 1997; ISSN 095-6947

NISTIR 5329. Manual for Ventilation Assessment in Mechanically Ventilated Commercial Buildings

USEPA. An Office Building Occupant's Guide to Indoor Air Quality. United States Environmental Protection Agency; Office of Air and Radiation (OAR); Indoor Environments Division (6604J); EPA-402-K-97-003, October 1997

Wyon, David P. Enhancing Productivity while Reducing Energy Use Technical University of Denmark

Ventilation Air Quality

IEQ-4-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:**
Documentation is attached that indicates that the requirements of Section 5, 'Best Practices for Maintaining IEQ' of the International Performance Measurement & Verification Protocol, Volume II 'Concepts and Practices for Improved Indoor Environmental Quality', March 2002 have been met.

☐ **Required Component:**
The capability of the ventilation system to default to 100% outside air at all times has been provided where practicable and in balance with energy conservation.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Purpose: To provide minimum standards for the air quality of building areas upon occupancy.

Action: Implement a Construction Indoor Air Quality Management Plan in conformance with NY State EO-111reference to NYSGBTC 638.7(d)(2) and the USGBC LEED 2.1 Rating System. During construction, meet or exceed the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3. Use high efficiency filtration media at all unsealed HVAC return air grilles during construction and replace all building mechanical system filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy.

On completion of construction and prior to occupancy, conduct a one-week flush out using 100% outside air, in accordance with NYSGBTC 638.7(g)(1). Replace all filtration media used with new MERV 13 filters. Test indoor air quality at random sampling points for every 20,000 sf, or by each floor if smaller, in accordance with recognized national standards, to achieve an air quality profile at time of occupancy which satisfies the specific minimums for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon as per NY State EO-111 reference to NYSGBTC 638.7(d)(2) and include one additional testing procedure for 4-PCh to satisfy all of the Alternate Procedure Requirements for LEED 2.1. Where concentration levels of contaminants exceed the established parameters in any specific area, flush out area with 100% outside air for a minimum of two weeks and retest until a satisfactory result is achieved.

Proposed Changes:

Purpose: To provide minimum standards for the air quality in the building during construction and upon occupancy.

Action: Implement a Construction Indoor Air Quality Management Plan in conformance with NY State EO-111reference to NYSGBTC 638.7(d)(2) and the USGBC LEED 2.1 Rating System. During construction, meet or exceed the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3. Use high efficiency filtration media at all unsealed HVAC return air grilles during construction and replace all building mechanical systems filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy.

On completion of construction and prior to occupancy, conduct a one-week flush out using 100% outside air, in accordance with NYSGBTC 638.7(g)(1). Replace all filtration media used with new MERV 13 filters. Test indoor air quality at random sampling points for every 20,000 sf, or by each floor if smaller, in accordance with recognized national standards, to achieve an air quality profile at time of occupancy which satisfies the specific minimums for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon as per NY State EO-111 reference to NYSGBTC 638.7(d)(2). Include one additional testing procedure for 4-PCh to satisfy all of the Alternate Procedure Requirements for LEED 2.1. Where concentration levels of contaminants exceed the established parameters in any specific area, flush out area with 100% outside air for a minimum of two weeks and retest until a satisfactory result is achieved.

Related Guidelines: UEQ-8, SEQ-5, SEQ-6, IEQ-1, IEQ-3, IEQ-6, IEQ-7

Potential LEED™ 2.1 Credits: 2 possible with EQ cr. 3.1 and EQ cr. 3.2. (See Submittal Template)

Introduction/Context

Construction practices generate dirt, dust, and debris and release particulates, gasses and volatile organic compounds (VOC's) into the air-stream. The presence of moisture within the building can generate and support conditions which allow mold and mildew to establish a foothold, often creating conditions that are difficult to remediate and which affect the quality of IAQ in the building for years to follow. This credit outlines a series of strategies intended to minimize the potential for generation of construction-related pollution and to assist in the containment and removal of any contaminant sources prior to occupancy.

During the construction of new buildings and major renovations of existing buildings, the fabric of the building and its mechanical systems and services, as well as building materials and products, must be physically protected from potential contamination and exposure to moisture. By developing a rigorous Construction IAQ Management Plan, and enforcing its requirements, this can be achieved. The plan must address all issues relating to potential contamination, including protection of the building fabric and systems, use of cleaner or more benign building materials to reduce loads, sequencing of material flows and avoidance of damp or wet conditions...

In compliance with the NYSGBTC 638.7 (g) (1), on completion of the work, and prior to occupancy the building must be flushed out with 100% outside air using clean filtration media for a period of one week. Following this purge, within thirty days of occupancy of either a new or renovated building or tenant space, indoor air quality testing *must* be performed to determine that levels of carbon dioxide (CO_2), carbon monoxide (CO), formaldehyde (HCHO), particulate matter, radon and total volatile organic compounds (TVOC's) are acceptable. Pollutant levels must be at, or less than, those cited in the standards referenced in this credit.

Relevant Issues

Ecological
The protection of air quality during construction is critically important for the future air quality in the building and for the comfort and safety of those who will later occupy the building. It also addresses immediate concerns relative to the well-being of construction workers. By adhering to a rigorous schedule of protective measures that minimizes the presence of toxic materials, reduces and contains contaminants, dust and debris, isolates sensitive equipment and systems, and protects building materials from wet conditions, the design team and construction personnel establish baseline conditions for a clean, well-managed building site. This in turn goes a long way to creating safer working conditions for construction crews and a healthy building for future occupants.

Economic
Many of the strategies in a Construction IAQ Management Plan, in fact reduce potentials for expensive errors at the site, and protect the building from future costly clean-up. Protective measures incur minor costs associated with the purchase of appropriate products, as well as the labor required to move, isolate, cover and generally protect vulnerable materials, systems and equipment from exposure to rain, dust, grit and VOC's generated by construction activities. These costs are a much less expensive alternative to the potential costs associated with the clean-up and/or replacement of damaged or soiled materials and equipment, and especially those that have been subjected to wet conditions at the site.

Of particular concern are factors relating to water damage of HVAC equipment, and to conditions that allow the absorption of moisture by soft or porous materials. The functionality of equipment so damaged can be compromised, while both water-damaged equipment and materials have the potential to support the growth of microorganisms that can lead to mold and mildew in the building. Subsequently, as the building becomes enclosed and warmer, the presence of these contaminants can cause Building Related Illness (BRI), a well-recognized condition which can seriously affect the health of occupants – i.e. Legionnaire's Disease or pneumonitis. It is critical for both economic and health factors that appropriate measures to prevent these conditions from occurring are described in the Construction IAQ Management Plan and, most importantly, are enforced at the job site.

Neighborhood
Maintaining a clean worksite and taking steps to reduce and contain dust-generating activities helps to protect the health of construction workers, as well as occupants in nearby buildings. In addition, utilizing low-VOC products means that workers are exposed to less noxious materials and to lower levels of off-gassing during the construction process. The Occupational Safety and Health Administration (OSHA) regulates conditions required to meet minimum worker safety and health measures, however, a sustainable project seeks to exceed these *minimum* standards wherever appropriate and possible.

Building Related Illness (BRI) is an extremely difficult condition to rectify, requiring a costly remediation process. Once a structure is contaminated by microorganisms, which generally results in the – often unseen -- presence of mold and fungus, not only is a rigorous and complicated clean-up necessary, the perceived 'reputation' of the building is greatly affected, making it lose market value. Avoiding conditions that allow microorganism communities to grow and flourish in the building is an important preventive action and a pro-active way to support human health and well-being.

Methodology

Design Strategies

A Construction IAQ Management Plan calls for the protection of materials and particularly systems-related equipment as they arrive at the site, are temporarily stored and subsequently installed. All products must be kept clean, dry and undamaged in secure storage areas not affected by construction activities and/or exposed to wet or humid weather conditions. Materials and equipment must also be protected during and after installation, as work often continues in the immediate vicinity around the newly installed items. These measures need to remain in effect until such time as the project is considered to be substantially complete, and the building is clean, flushed out and occupied.

Specifications must include either a comprehensive Construction IAQ Management Plan prepared by the architect, or call for the preparation of such a Plan by the general contractor (GC) or construction manager (CM). The latter option is preferred as the implementation and management of the Plan is ultimately the responsibility of the GC or CM. In either case, the architect and the responsible GC/CM must approve the plan.

The contractor is responsible for establishing a communication pathway between all concerned parties (owner, tenant, design professionals, sub-contractors and their on-site personnel, etc) to discuss and resolve any potential IAQ issues relative to site activities. He or she must ensure that all sub-contractors are aware of, understand and adhere to the instructions outlined in the plan.

The Tax Credit calls for the designation of a representative (also known as an IAQ Manager) with daily responsibility for IAQ issues [NYSGBTC (638.7)(d)(2)(3)(i)]. This task involves the observation, supervision and follow-through on the specific requirements of the Construction IAQ Management Plan. The IAQ Manager will be responsible for advising those in authority if conditions that threaten air quality or that might affect the integrity of materials and/or systems are observed, or when procedures outlined in the Construction IAQ Management Plan are not being followed.

Implementation of the Plan begins in the design and pre-construction phases, where construction details addressing the continuity of the moisture protection strategy between joints is required to be in compliance with NYSGBTC 638.7(d) (2), and the level of construction detail must be as provided by the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction', Chapter 3, Fifth Edition. In addition, in these early phases, low-emitting materials are selected and specified (source control), and during the pre-construction planning, the sequencing for maximum protection of materials and related processes is developed. The SMACNA IAQ Guideline will be a key reference document for this credit.

Means and Methods

Design Strategies (Construction Drawings)

Drawings detailing the continuity of moisture protection strategies at the building envelope must cover all joints between dissimilar materials. Drawings must be three-dimensional when envelope and moisture protection planes intersect in 3 dimensions. Construction details must meet the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association, Architectural Sheet Metal Manual, 5th Edition, 1993.

Control Strategies (During Construction)

<u>Source Control</u>
Work with design team to recommend specification of low-VOC sealants, adhesives, caulks, coatings, paints, cleaning solutions, etc. Provide adequate ventilation of work areas. Modify equipment usage or work techniques to minimize pollution and dust and isolate or seal-off completed areas from on-going construction work. This may include filtering exhaust or exhausting directly to the outdoors. Cover and seal containers of wet products when not being utilized.

<u>Pathway interruption</u>
Provide 100 percent outside air and continuously run HVAC equipment during installation of materials and finishes, beginning after the building is substantially closed. Where a supply air system is already installed, it must have filters in place before work begins. The permanent HVAC system may be used to move both supply and return air provided the following conditions are met. Replace all construction-related filtration media used on permanent HVAC equipment at substantial completion of work. Confirm that all air filters, casing, coils, fans and ducts are clean, before TAB and air quality testing. Permanent air supply ducts must be inspected and/or cleaned to comply with the minimum requirements of "General Specifications for the Cleaning of HVAC Systems" published by the National Air Duct Cleaning Association.

<u>HVAC protection</u>
Protect the ventilation system components and air pathways against contamination during construction. When possible keep system off during heavy construction (only turning it on for installation of finishes, etc. as noted above). Return system openings in and adjacent to construction areas should be sealed. Use high efficiency filtration media at all HVAC return air grilles during construction. Implement cleaning procedures for ventilation system components prior to occupancy in the event that ventilation pathways were not adequately protected during construction.

<u>Good Housekeeping</u>
Store building materials in a weather-tight, clean area protected from dust, debris and moisture. Keep the premises free from accumulations of waste materials, rubbish, recyclables and other debris resulting from work. Identify the storage, disposal and housekeeping practices to be applied to building supplies and waste materials to protect building systems from contamination.

Scheduling

Permit adequate drying time for new materials. Sequence the installation of finish materials. Install concrete during unoccupied periods and allow it to cure properly before sealing or covering. Schedule work to ensure that building occupancy is avoided while construction-related pollutants are still present. Submit a construction schedule that addresses the sequencing of absorbent finishes so that they will not act as sinks for the storage and subsequent release of contaminants emitted from solvent-based and other toxic materials, which typically occurs when the building is enclosed and warmer.

IAQ test procedure

The IAQ test procedure as defined in the NYSGBTC requires the testing of indoor air quality at random sampling points for every 20,000 square feet, or by each floor if smaller, or by each separate ventilation zone, in accordance with recognized national standards. Both base building projects and tenant fit-outs must comply with the testing requirements. Each standard includes an appropriate protocol and describes conditions under which the test must be conducted by a professional IAQ expert or industrial hygienist. At the time of occupancy, an air quality profile which satisfies the specific minimum standards for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon as per NYSGBTC 638.7(d)(2) must be met. In addition, for those projects pursuing a LEED Certification, one further test procedure for 4-PCh to satisfy all of the Alternate Procedure Requirements for LEED 2.1 must be completed. Where concentration levels of contaminants exceed the established parameters in any specific area, that area must be flushed out with 100% outside air for a minimum of two weeks and retested until a satisfactory result in line with the minimum contaminant level(s) is achieved. The test standards are listed in the following table:

Indoor Air Quality Standards for New York City Green Building Tax Credit (Abbreviated)

Substance	**Criteria**	**Standard and Source**
Carbon Dioxide	700 ppm above background	ASHRAE 62-1999
Carbon Monoxide	Indoor levels not to exceed background. Background (outside air) at intakes not to exceed: 1) 9 ppm/8-hour average, or 2) 35 ppm/1-hour average	EPA National Ambient Air Quality Standards New York State Air Quality Standards ASHRAE 62-1999
Formaldehyde	50 ppb (parts per billion)	EPA Building Assessment Survey and Evaluation California Resources Board IAQ Guideline

Particulates	150 micrograms per cubic meter (150 ug/m³) 24-hour average	EPA National Ambient Air Quality Standards ASHRAE 62-1999
Radon*	4 picocuries per liter	EPA – Radon Reduction Techniques for Detached Houses Technical Guidance ASHRAE 62-1999
Total Volatile Organic Compounds	200 micrograms per cubic meter (200 ug/m³) above background	EPA Research Triangle Park Research and Administrative Facility Baseline Testing, 2001
4-PCH (4-Phenyl-cyclohexene	6.6 micrograms per cubic meter (6.5 ug/m³)	State of Washington IAQ Standard

*Radon Tests need not be repeated if readings of less than 4 picocuries per liter were recorded during the first test.

WTC Guidelines (Including EO 111 & NYSGBTC Requirements):

1. NYSGBTC 638.7(d) (2): This section of the Tax Credit describes Indoor Air Quality Testing. IAQ testing is required to take place within 30 days of occupancy, and subsequently, except as noted above, on an annual basis for the first five years of occupancy. Testing must be done in accordance with the listed procedures and standards, and must meet the established IAQ limits for carbon dioxide, carbon monoxide, formaldehyde, particulate matter, radon (as noted) and TVOC's.

2. NYSGBTC 638.7(g)(1): In addition, and prior to the mandatory testing noted above, a minimum one-week purge (seven days/twenty four hours) must be completed on every floor, prior to occupancy. This purge must occur with air handlers operating at 100 percent outside air, at 50 percent of the full airflow rate of the fan when the outside temperature falls between 55 and 85 degrees Fahrenheit and the relative humidity is between 30 and 60 percent. When the outside air temperature and relative humidity fall outside these ranges, the fan air flow rate may be operated at a minimum of 25 percent, during typical operating conditions.

Case Studies

Premier Automotive Group North American Headquarters, Irvine California

A Construction IAQ Management Plan was designed at the beginning of the project and adhered to throughout construction of this office and design center for Ford Motor Company. Measures were taken to protect all ductwork and any permeable materials that were stored on site. These items were protected from chemical contaminants, as well as from exposure to moisture, which could lead to future problems with mold and mildew. Before the building was occupied a two-week building flush-out was performed to remove any airborne contaminants and all filtration media was subsequently replaced. (USGBC 2005)

The Patrick H. Dollard Health Center, Harris New York
This building, the first in New York State to employ green building standards that conform to Department of Health requirements, provides specialized medical care for 250 residents. To ensure a healthy environment for these occupants, a Construction IAQ Management Plan was followed. Material Safety Data Sheets for all construction materials were reviewed prior to construction to insure that workers and future building occupants would be exposed to only the minimal amount of dangerous pollutants. No urea-formaldehyde-based plywood underlayment was used on any of the building's floor surfaces. All uncoated paper products, absorbent materials and textiles stored on site during construction were protected from both moisture and exposure to high VOC concentrations. After painting was completed, the construction team waited for a minimum of three days before installing absorptive interior furnishings such as carpet. (BuildingGreen 2005)

Reference

Definitions

Sick Building Syndrome (SBS)

Term that refers to a set of symptoms that affect some number of building occupants during the time they spend in the building and diminish or go away during periods when they leave the building. Cannot be traced to specific pollutants or sources within the building. (Contrast with "Building related illness").

Building Related Illness (BRI)

Specific, identified maladies attributed to an identified material, product or system in a home or building. Examples include Legionnaire's Disease, hypersensitivity pneumonitis, humidifier fever, and asthma-like symptoms in non-asthmatic individuals.

Note: *There is a lot of confusion between the terms 'SBS" and 'BRI'. Simply stated, BRI results in recognizable, often serious disease or even chronic illness, while SBS refers to a condition of malaise or physical discomfort, which is generally temporary and limited to time spent in the building.*

Pneumonitis: inflammation of the lungs, which occurs secondary to exposure to a chemical, organic dust, fungus or mold. Chronic exposure can lead to chronic lung changes evident on chest X-rays. Symptoms include cough, fever, shortness of breath and wheezing.

TAB Testing, Adjusting and Balancing of the HVAC system.

Standards

ASHRAE. ANSI/ASHRAE 52.2-1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. Atlanta: ASHRAE, 1999.

Sheet Metal and Air Conditioning National Contractors Association. IAQ Guideline for Occupied Buildings under Construction. Chapter 3, 5th Edition. Chantilly, VA: SMACNA, 1995.

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BuildingGreen.com. "The Patrick H. Dollard Health Center." BuildingGreen.com – HPB Case Study: Indoor Environment. May 2004. BuildingGreen, Inc. 13 January 2005. <http://www.buildinggreen.com/hpb/indoorenv.cfm?ProjectID=233>

USGBC. "Premier Automotive Group North American Headquarters." LEED Certified Project List. USGBC. 13 January 2005. <http://www.usgbc.org/Docs/Certified_Projects/Cert_Unreg19.pdf>

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Objectives

The Construction Indoor Air Quality Management Plan provides a tool to ensure that minimum indoor air quality standards are met upon building occupancy. The plan is intended to assist project teams in meeting the requirements of NYSGBTC 638.7(d)(2) and LEED EQ c3.1 and EQ c3.2, and incorporates the recommended Design Approach of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guideline for Occupied Buildings under Construction, Chapter 3.

Plan Components

I. Plan Description and Coordination

A. Provide description of project objectives.
B. Indicate team responsibilities and primary participants (owner, architect/engineer, contractor, etc.) and daily responsibilities. Specific Authority must be designated for coordinating plan requirements and achieving plan objectives. This Authority must include jobsite inspections with the ability to implement stop work orders for nonconformance with the Plan.
C. Establish means of communication and notification between all parties to prevent and resolve IAQ difficulties.
D. Provide schedule overview.

II. Design Strategies (construction drawings)

Ensure that the following requirements have been met as part of the Construction Documentation.

A. Drawings detailing the continuity of moisture protection strategies at the building envelope must cover all joints between dissimilar materials.
B. Drawings must be three-dimensional when envelope and moisture protection planes intersect in 3 dimensions.
C. Construction details must meet the minimum requirements of the Sheet Metal and Air Conditioning National Contractors Association, Architectural Sheet Metal Manual, 5th Edition, 1993.
D. Specifications include the requirements of this plan.

III. Control Strategies (during construction)

A. Source Control
   1. Specifications must clearly indicate the requirement for use of low VOC sealants, adhesives, caulks, coatings, paints, cleaning solutions, etc.
   2. Indicate the methods by which adequate ventilation at work areas will be provided.

3. Indicate source control strategies used to minimize dust and air-borne pollution, including any modification of equipment usage or work techniques, such as the installation of temporary space dividers between construction and non-construction areas of the site, filtering exhaust and/or exhausting directly to the outdoors.
4. Indicate strategies for the protection of volatile substances and minimization of air pollution from containers of wet products when not being utilized.

B. Pathway interruption
1. Provide data indicating that the fans will be run continuously using 100 percent outside air during installation of materials and finishes, beginning after the building is substantially closed. When the outside temperature is between 55 and 85 degrees Fahrenheit and the relative humidity is between 30 and 60 percent the fan airflow rate must be operating at 50 percent capacity. When the outside air temperature and relative humidity fall outside these ranges, the fan air flow rate may be operated at a minimum of 25 percent, during typical operating conditions. Where a supply air system is already installed, it must have filters in place before work begins.
2. The permanent HVAC system may be used to move both supply and return air: Indicate in the drawings and specifications that the following conditions will be met during construction:
   a. Replace all construction-related filtration media used on permanent HVAC equipment at substantial completion of work
   b. Confirm that all air filters, casings, coils, fans and ducts are clean, before TAB and air quality testing. Permanent air supply ducts must be inspected and/or cleaned to comply with the minimum requirements of "General Specifications for the Cleaning of HVAC Systems" published by the National Air Duct Cleaning Association.

C. HVAC protection - Ventilation system components and air pathways must be protected against contamination during construction. Provide documentation indicating that the following or similar strategies will be employed:
1. When possible keep system off during heavy construction.
2. Return system openings in and adjacent to construction areas will be sealed.
3. Use of high efficiency filtration media at all HVAC return air grilles during construction.
4. Identify cleaning procedures for ventilation system components to be employed prior to occupancy in the event that ventilation pathways were not adequately protected.

D. Good Housekeeping
1. Indicate on the drawings the location of a storage space for building materials, which will be weather-tight, clean and in an area protected from dust, debris and moisture change.
2. Include a requirement to maintain the premises free from accumulations of waste materials, rubbish, recyclables and other debris resulting from work. Identify the storage, disposal and housekeeping practices to be applied to building supplies and waste materials to protect building systems from contamination

E. Scheduling – Indicate on the drawings and/or in the specifications how the following strategies will be achieved
1. Adequate airing-out of new materials

2. Sequencing of the installation of finish materials to minimize absorption of contaminants
3. Time allowance for proper curing of concrete before sealing or covering
4. Scheduling of wet trades and installation and finish materials during unoccupied periods
5. Avoidance of building occupancy while construction-related pollutants are still present.
6. Submit a special construction schedule to prevent absorptive finishes from acting as sinks for storage and subsequent release of contaminants emitted from sealants and other toxic finishes and processes.

IV. Before and Immediately Following Occupancy

A. On completion of construction prior to occupancy, conduct a one-week minimum flush out with new MERV 13 filtration media and using 100% outside air, in accordance with NYSGBTC 638.7(d) (2).
B. Replace all base building mechanical system filtration media with Minimum Efficiency Reporting Value of 13 (MERV 13) filters in accordance with ASHRAE 52.2 – 1999 immediately prior to occupancy
C. On completion of construction and within 30 days of occupancy, conduct an IAQ test in accordance with NYSGBTC 638.7(d) (2). Test indoor air quality at random sampling points for every 20,000 sf, or by each floor if smaller, or by each ventilation zone, in accordance with recognized national standards, to achieve an air quality profile at time of occupancy which satisfies the specific minimums for carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds, particulates and radon.

V. Strategy Coordination

A. Outline the scope of the IAQ Management process during construction, including submittal review, inspection and enforcement
B. Outline the expected written work products, including checklists and worksheets
C. Provide an activities schedule.
D. Provide a schedule of IAQ Management Plan meetings for every phase of the project..
E. Outline the IAQ-related training programs that will be provided for the trades.

VI. Management Report

The Construction Indoor Air Quality Management Report documents effective implementation of the Plan. The following documentation is required as part of this report.

A. Meeting minutes, checklists, worksheets, notifications and deficiency or resolution logs related to IAQ issues.
B. Log with all temporary uses of building mechanical plant and filter replacements during construction and prior to occupancy. Include cut sheets of filter media.
C. Progress photographs documenting IAQ measures implemented during construction*.
D. Documentation and log of duct inspection, testing and cleaning, where necessary.

Construction IAQ Management **IEQ-5-T**

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase: SD ☐ DD ☐ CD ☐ FINAL ☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 3.1: Construction IAQ Management Plan – During Construction)*
This certifies that a Construction Indoor Air Quality Management plan has been implemented and will satisfy all of the criteria outlined in the Methodology Section of Sustainable Design Guideline IEQ-5.

Note 1: *in order to satisfy the requirements of NYSGBTC 638.7(d), both a one week pre-occupancy flush-out **and** an IAQ test to occur within 30 days of occupancy (as described in the NYSGBTC) are required to be completed.*

☐ **Optional Component:** (To satisfy *the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 3.2: Construction IAQ Management Plan – After Construction/Before Occupancy.)*
A two-week flush out with new filtration media using 100% outside air has been completed after construction and prior to occupancy. After purging the building, all filtration media were replaced with new MERV 13 filters.

Alternatively, immediately prior to occupancy, conduct a baseline IAQ testing procedure in accordance with LEEDCI v2. EQ c3.2, which includes testing for 4-PCH, and demonstrates that the listed chemical contaminants are at or below the thresholds established by the referenced standards.

Note 2: *The LEED v2.1 credit language calls for the IAQ test to be conducted prior to occupancy. Through the LEED CIR process, the USGBC will accept that the IAQ test may be conducted immediately following occupancy, which complies with the NYSGBTC.*

Name

Signature

Company

Role in Project

Date

Reduce Contaminants from Materials IEQ-6

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To reduce the density of contaminants that are emitted by common building materials and which affect the comfort and well-being of building occupants.

Action: Develop and implement a Materials Management Plan to minimize utilization of materials with high levels of volatile organic compounds (VOC's) and other toxic characteristics, which adversely affect Indoor Air Quality (IAQ). VOC's must meet or be lower than those in the following standards:

Adhesives and Sealants	**Current Version**
Adhesives and Sealants	South Coast Air Quality Management District Rule #1168
Paints and Coatings	
Paint topcoats	Green Seal GS-11
Primers, undercoats, sealers, coatings	South Coast Air Quality Management District Rule #1113
Anti-Corrosive paints	Green Seal GS-3
Carpet, Carpet Cushion and Adhesives	
Carpet and Carpet Tile	Carpet & Rug Institute's (CRI) 'Green Label Plus' Indoor Air Testing Program
Carpet Cushion	Carpet & Rug Institute's (CRI) 'Green Label' Indoor Air Testing Program
Carpet Adhesives	South Coast Air Quality Management District Rule #1168

Where possible use non-urea-formaldehyde-based bonding agents in composite wood and typical millwork applications, such as veneer and plastic laminate applications, etc.

Do not use unprotected insulation in ducts, supply plenums and return plenums per NYSGBTC 638.7(j).

Related Guidelines: SEQ-1, MEQ-3, MEQ-4, MEQ-6, MEQ-7, IEQ-1, IEQ-3, IEQ-4, IEQ-5

Potential LEED™ 2.1 Credits: 4 possible with EQ cr. 4.1, EQ cr. 4.2, EQ cr. 4.3, and EQ cr. 4.4 (See Submittal Template)

Introduction/Context

One of the major goals of all green building guidelines is to introduce a series of means and methodologies that diminish the deleterious effect of the built environment on the natural environment and to enhance conditions for human well-being. Within this context, efforts are made to reduce the use of building materials and products that pollute the air, earth and water. These impacts occur at various times, including during manufacturing processes, transportation, use in construction and/or as impacts within the building, as well as during the final disposal of such products. The four credits in IEQ-6 'Reduce Contaminants from Materials' establish preliminary guidelines for reducing negative impacts from a number of common building material sources on both outdoor and indoor air quality.

Relevant Issues

Ecological

The term 'low-emitting materials' generally refers to products that are low in volatile organic compounds (VOCs) and other airborne toxins, and which minimize contributions to the development of ground ozone or smog. The major areas of concern include the 'wet trades' – paints, coatings,adhesives, glues, caulks and sealants -- as well as carpet systems and engineered woods. Traditionally, all of these products have been made with highly toxic chemicals with the potential to adversely affect human health when concentrated inside buildings, and which, in the case of VOC's, contribute to ground ozone, a major factor in the development of smog. The association between smog and asthma is well documented (see the EPA's brochure: 'Ozone and Your Health').

Ground level or 'bad' ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of VOCs, however, many common building materials also emit these solvents.

Economic

Within the three categories indicated in the chart above, plus non-urea-formaldehyde-based bonding agents, there are now many options for 'low-emitting materials'. Today, because of competition between manufacturers, there is little or no penalty in terms of cost for requiring the use of environmentally preferable products. Using low-emitting materials, and especially those low in VOC's, contributes to enhanced indoor air quality (reduced loads) and the release of less smog generating chemicals. These factors contribute to increased occupant satisfaction, comfort and productivity in buildings, and less ground-level smog with its associated health risks. These in turn are important economic considerations.

Neighborhood

Creating a greater demand for low-emitting products is an effective way to stimulate industry to continue its 'clean up', while providing the market with a wider choice of environmentally superior products. Not only are building occupants found to be more satisfied with their work and learning environments when there is high indoor air quality, the reduction of toxic chemicals in building materials such as urea-formaldehyde, toluene, benzene, etc. makes for environmentally cleaner manufacturing facilities and safer working conditions for factory workers. Reduced ground-level smog provides a significant community benefit, especially in densely populated, urban areas such as New York City.

Methodology

Design Strategies

These four areas of concern, which fall collectively under the umbrella of IEQ-6, are intended to address products used in the building interior only. They focus on the impact of several interior grade materials which, when made with traditional methods and materials, have the potential to be major pollutant emitters, adversely affecting indoor air quality. The definition of 'indoor' is described as 'all products and materials that are installed inside the weather barrier', and includes interior duct linings, as well as the interior portion of exterior wall construction, thermal insulation, etc. While it is acknowledged that the state of the construction manufacturing industry is not yet at a stage where there are multiple choices for environmentally clean *exterior* building materials, design teams are encouraged to consider the advantages of specifying cleaner building materials throughout the project.

Specifications can be written to include an environmental section in Division 1 requiring the use of environmentally cleaner materials. Both construction materials, such as adhesives and composite wood panels, and interior finish materials such as paint and carpet are included. Language to address each environmental concern can be added to the relevant specification section dealing with paints, coatings, adhesives, sealants, carpet assemblies and composite and engineered wood products.

It is important to consider the full spectrum of each material or product's characteristics, including suitability, aesthetics and demonstrated performance or durability, as well as ease of maintenance, while considering its environmental, low-emitting potential.

Means and Methods

Research into environmentally cleaner materials has become increasingly manageable as a result of readily availably technical data sheets and material safety data sheets (MSDs). These two documents, which can be obtained from manufacturers, generally provide environmental information relative to VOC content of the product in grams per liter (g/L), and also list chemicals that are known to be highly toxic and/or which might appear on the banned or restricted lists as indicated in the relevant standards.

Products that fall within these four areas of concern require careful recordkeeping. Information relative to each product, including technical data, VOC counts and evidence of chemical component compliance must be obtained and kept. If there is a long period between original specification and purchase of any product for installation, the environmental considerations for each such product or material will need to be rechecked to make sure that there has been no change in manufacturing that would affect the product's compliance with the standards.

Once an environmentally compliant material has been approved for use, it needs to be tracked to ensure that there is no field or contractor substitution and that the installed product meets the environmental requirements as specified.

Reference

Definitions

Volatile Organic Compounds (VOCs) The term 'Volatile Organic Compounds', often referred to as VOCs, means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.
Source: Ron Josephs and Associates

Formaldehyde A colorless gaseous compound, HCHO, the simplest aldehyde, used for manufacturing melamine and phenolic resins, fertilizers, dyes, and embalming fluids and in aqueous solution as a preservative and disinfectant.
Source: The American Heritage® Dictionary of the English Language, Fourth Edition Copyright © 2000 by Houghton Mifflin Company.

As used in building materials, this chemical is found in many materials, and is frequently used as a binding agent in engineered and composite wood products, as well as a form of biocide in insulation, ceiling tiles, fabric finishing, etc. It comes in two common forms: **urea formaldehyde** used for interior products, and **phenol formaldehyde** used primarily in exterior products. Both forms of formaldehyde are confirmed human carcinogens (IARC, DFG). Urea formaldehyde releases volatile gasses (out-gasses) at room temperature, while phenol formaldehyde requires much greater levels of heat in order to become volatile.

Standards & Bibliography

South Coast Air Quality Management District Rule 1168 (SCAQMD)
This Standard addresses a reduction in VOC levels and has some chemical limitations. Although it does consider the impact of some chemicals, it is not an ideal standard for the purposes of developing criteria for 'green' buildings, as it does not consider the comprehensive health impacts of toxic chemical emissions. However, SCAQMD Rule 1168 does require a reduction in typical VOC emissions, and therefore contributes to the reduced use of toxic chemicals at manufacturing plants, cleaner indoor air and the reduction of ground-level smog.
SCAQMD Rule 1168 is up-dated periodically, with announcements of up-dates (more restrictive requirements) being noted well in advance.

Green Seal – GS-11
GS-11 sets VOC limits for interior opaque, topcoat paints.

Green Seal – GS-03
GS-03 addresses VOC limits for anti-corrosive paints on ferrous metal.

Both Green Seal standards set an Aromatic Hydrocarbon Compound limit of no more than 1% by weight and do not allow inclusion of the following substances.

Halomethanes; Methelene chloride

Chlorinated methanes; 1,1,1-trichloroethane

Aromatic solvents; Benzene**,** Toluene (methylbenzene), Ethylbenzene

Chlorinated ethylenes; Vinyl chloride

Polynuclear aromatics; Naphthalene

Chlorobenzenes; 1,2-dichlorobenzene

Phthalate esters; di (2-ethylhexyl) phthalate, butyl benzyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, diethyl phthalate and dimethyl phthalate

Semi-volatile organics; isophorone

Metals and metal compounds; antimony**,** cadmium**,** hexavalent chromium**,** lead and mercury

Preservatives; formaldehyde

Ketones; methyl ethyl ketone**;** methyl isobutyl ketone

Volatile organics; acrolein**,** acrylonitrile

South Coast Air Quality Management District Rule 1113 (SCAQMD)
SCAQMD Rule 1113 establishes a standard for primers, sealers and all other *architectural coatings*, including clear wood coatings and floor finishes, which are not included in the Green Seal Standards. The Standard lists permissible VOC content levels and chemicals limited by weight or totally restricted for use in these products. SCAQMD Rule 1113 is up-dated periodically, with announcements of up-dates (more restrictive requirements) being noted well in advance.

Carpet & Rug Institute (CRI) 'Green Label Plus' Indoor Air Test Program
In 2004, the CRI introduced a more rigorous and demanding carpet testing program – Green Label Plus -- which will be administered in the same manner as the CRI's original 'Green Label' program. At this time, only carpet (top material) is tested under the Green Label Plus program, which limits emissions from thirteen (13) chemicals known to have negative IAQ impacts, and which are commonly associated with carpet manufacture.

Note: The Green Label Plus standard has been adopted for use by LEED v2.2, CI, EB and all future products, as the original Green Label standard no longer represents a significant sustainable challenge and all projects using carpet were able to achieve the credit.

Carpet & Rug Institute (CRI) 'Green Label' Indoor Air Test Program

The CRI's Green Label Indoor Air Test Program will remain in place for Carpet Cushion until such time as the more comprehensive Green Label Plus program becomes available for these products. Adhesives used in the carpet and/or cushion installation under either CRI program must conform to the requirements of SCAQMD Rule 1168.

Reduce Contaminants from Materials — IEQ-6-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:** *(This will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credits 4.1, 4.2, and 4.3: Low-Emitting Materials –Adhesives and Sealants, Paints and Coatings, and Carpet.)*
A matrix listing of all interior paints and coatings and adhesives and sealants used on the project is attached. The matrix has been completed indicating the manufacturer for each product listed, product identification name and/or number, VOC count in grams per liter (g/L) and use for each product. This certifies that the products used meet the chemical component limits of the restricted substances listed in the standards that have been listed, and the amount of restricted chemical content by weight has not been exceeded.

The identifying names and certification numbers indicating that all carpets and carpet systems used on the project are in compliance with the requirements of the Carpet and Rug Institute's IAQ Test Program are attached.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credits 4.4: Low-Emitting Materials – Composite Wood.)*
A list of all the composite wood products used in the building is attached. This certifies that they contain no added urea-formaldehyde resins.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Purpose: To minimize sources of chemical and particulate air contamination.

Action: Design all major entrances with permanent walk-off grilles to minimize particulate transfer. Provide MERV 13 air filters for removal of 90% of particulates at air supply systems and provide building owner with a maintenance schedule for filter replacement. Build slab-to-slab partitions and provide negative air pressure of at least 7PA with isolated exhaust systems of at least 0.5cfm/sf at workrooms with printing and copying equipment, janitorial closets and all chemical use areas. Locate exhausts to ensure that there is no potential for re-entrainment of exhaust air to other supply in-takes. Provide drains for appropriate disposal of liquid waste in spaces where water and chemical concentrate mixing occurs.

Related Guidelines: UEQ-8, EEQ-6, IEQ-1, IEQ-3, IEQ-4, IEQ-5

Potential LEED™ 2.1 Credit: 1 possible with EQ cr. 5 (See Submittal Template)

Introduction/Context

Air in indoor environments is said to be as much as 1,000 times more contaminated than outside air (EPA: Office Equipment: Design, Indoor Air Emissions and Pollution Prevention Opportunities). Low outside air ventilation rates, minimum air changes per hour and limited paths for removal and replacement of contaminant-laden air, along with indoor activities and the operation of equipment, all contribute to the concentration of pollutants within the building. There are many strategies available for the clean-up of the indoor environment, but one of the simplest and most effective is to prevent airborne contaminants and particulates from entering the building in the first place. This can be accomplished, to some degree, through the design of the building and its systems. By building-in measures such as permanent, recessed walk-off grilles at all major entrances, with effective mat material to capture dirt carried on shoes, much particulate matter is prevented from entering the building. Installing high quality filtration media at all air in-takes, and establishing a rigorous maintenance schedule for filter replacement protects indoor air from many common air-borne contaminants.

Many typical activities and office functions that take place within the building also generate pollution, which affects the quality of the indoor environment. Isolating areas where contaminants are typically generated, such as copy and printing areas, and janitorial closets, while carefully managing liquid chemical contaminants and their disposal, goes a long way to making the indoor environment a safer and more comfortable place for human occupation.

Relevant Issues

Ecological

There is little downside to planning for enhanced indoor environmental quality in terms of cleaner air, and considerable reason to include these strategies at an early stage in the design of the project. While the strategies indicated require the use of marginally more raw materials in the construction of the building, the payback in terms of reduced sick building syndrome (SBS), occupant satisfaction with the indoor environment, and in associated productivity, will be significant. Preventing contamination of the water supply is an important health and safely issue, as well as a critical environmental strategy with far-reaching consequences for the natural environment (well beyond the immediate area of the project).

Economic

The design and construction of recessed entryway grilles is in line with best practice in Class A buildings in Manhattan and elsewhere. There is, therefore, no anticipated increased cost impact associated with this strategy for the World Trade Center buildings. Costs associated with the construction of slab-to-slab partitions and separate exhaust systems as required to isolate rooms where chemicals may be released as a result of office or building activities, will be off-set quickly by cleaner indoor air and associated productivity gains. MERV 13 (Minimum Efficiency Reporting Value) filters are more expensive than many other types of air filtration media. However, the performance of MERV 13 filters improves continuously over time. As these passive filters 'load-up', slightly more energy is expended to address their continually increasing resistance over their anticipated lifetime. This is a small penalty to pay when compared to the enhanced IAQ resulting from the use of this ASHRAE Standard 52.2-1999-supported filtration system. The provision of separate plumbing drains for specific chemicals at janitorial closets and other maintenance locations where such chemicals and cleaning/maintenance materials are handled, ensures that building occupants are not inadvertently exposed to these substances. Specialty drains for toxic chemicals, where required, are generally addressed by code and are designed to ensure that the water supply and natural bodies of water beyond the site location are not contaminated by untreated chemical waste.

Neighborhood

Although the issues discussed in this credit require consideration in both the design and construction phases of the building, they are really associated with 'good housekeeping'. Providing high quality indoor air by preventing the exposure of building occupants to air pollutants through design, construction and maintenance strategies has the potential to increase the life of the HVAC system, as well as contributing to the well-being of the building community. As a result, health care costs may be reduced. Managing chemical disposal and contaminated water through separate piping located away from public restrooms protects the building occupants from coming in contact with these substances, while appropriate measures for toxic chemical disposal helps to maintain and protect the water supply and nearby bodies of water such as the New York Harbor and estuaries.

Methodology

Design Strategies

Recesses to hold either permanent grilles with rough fiber 'brushes' or, at a minimum, permanently installed recessed walk-off mats need to be included in the design approach and are required at all heavily trafficked entrances to the building. The grilles must be removable so that the pit can be vacuumed out on a regular maintenance schedule. Mat recesses or floor cavities must be designed to a depth suitable to contain coir or other approved, permanently installed mats so that their surface is flush with the finished floor, in order to avoid tripping accidents. Steel or metal edges are recommended to prevent damage to the cavity edges. Mats must be cleanable and easily replaceable in case of heavy soiling, extreme wet conditions and/or damage. Removable walk-off mats laid on the floor during inclement weather do not meet the intent of this credit.

It is also recommended that the sidewalk immediately outside the building be sloped away from each entrance to minimize the potential for water intrusion and for water puddling and collecting in the pit below the grilles and/or in the mat cavities. Non-chemical, integrated pest management controls and low maintenance planting in and around entrance areas will diminish the potential for toxic chemicals being carried into the building via footwear and clothing.

Use of MERV 13 filters requires that the building HVAC system be designed to accommodate this passive technology at all air-intakes. Today, while there are many studies which suggest that dynamic and/or electrostatic filtration systems are comparable with these passive filters in terms of performance, evidence still indicates that MERV 13, and higher, filters provide significantly superior performance overtime. As the name implies, these filters are rated at their *minimum* initial performance level, which occurs when the filters are first installed, and continue to improve until they are replaced as part of an appropriately designed and pre-scheduled maintenance program. They remain as a preferred environmental technology. As of this date, ASHRAE 52.2-1999 addresses the performance of MERV rated filters only. There is no equivalent rating body for alternate filter systems.

Operation of copiers, printers, fax machines and other office equipment releases hydrocarbons, respirable particulates, ozone and VOC's to the indoor air (EPA Report, 1995 by Robert Hates, Mary Moore and Colleen Northeim). The objective of this portion of the credit is to contain and exhaust these airborne contaminants directly from the sources where they are generated. Design completely enclosed workrooms with slab-to-slab partitions where this type of equipment is to be located, and design similarly enclosed areas where janitorial work and the mixing of harsh chemicals may take place. Provide separate exhaust systems for each such space with a minimum ventilation rate of 0.5cfm per square foot. Negative pressurization of these workrooms and maintenance areas at 7PA relative to the areas surrounding them is also required to contain the contaminants. Minimize the locations of small, convenience printers and copiers that may be scattered throughout the offices to help maintain good air quality in the occupied space.

Most maintenance schedules do not call for the use of highly toxic chemical mixing. However, many apparently simple cleaning and maintenance products contain chemicals that have the potential to adversely affect human health, such as chlorine, formaldehyde, benzene, toluene and xylene, among others. These chemicals should be disposed of at designated locations such as 'wet' janitorial closets, using drains that are not in the public domain. Special activities, such as those that occur in photographic studios, large-scale print shops and/or specific factory applications may generate extremely toxic liquid waste. These materials should be drained separately and each drain used for this purpose needs to be numbered and tracked to its final point of treatment and/or disposal.

Means and Methods

Drawings and specifications require the inclusion of floor depressions to contain grille or grate entryway systems, or floor recesses to receive permanent walk-off mats, at all heavily trafficked entrances to the building.

ASHRAE Standard 52.2-1999 reviews methodologies for the effectiveness of passive air cleaners in removing particulates from the air-stream and for their resistance to airflow. As of this date, ASHRAE 52.2 does not include other filtration media or systems in this evaluation, making it difficult to establish efficiency and to compare performance of these systems with MERV filters.

> ***Note:*** *Neither LEED v2.1 nor LEED v2.2 (as currently planned) recognizes alternative filtration systems at this time. LEED v2.2 clarifies and reduces the number of filter changes necessary, and represents the preferred approach to compliance with the credit requirements.*

Design slab-to-slab enclosures for spaces containing large-scale office equipment and janitorial closets. Include a separate exhaust system for each such space with a ventilation rate of 0.5cfm per square foot minimum. In accordance with EO 111 and NYC Green Building Tax Credit, Part 638.7(h), ensure that these separate exhausts are at least 25 feet away from the building's air intake locations to prevent any re-entrainment of the exhaust air. Negatively pressurize these rooms at 7PA to prevent further the potential for contaminants to migrate into the occupied space beyond the containment zone.

Ensure that all areas intended for the storage and handling of building cleaning and maintenance chemicals have sinks and plumbing separate from the public or occupant restrooms. Architectural plans need to include storage areas and janitorial closets with adequate shelving and workspace for the storage of chemicals, cleaning materials and equipment. Bulk purchased, low-toxic cleaning products are preferred. Specialty toxic chemical handling areas, where these occur, must have drains that are separately plumbed and numbered so that in the case of a spill or flood, the source of the contaminant can be tracked and isolated.

Case Studies

<u>The Everett L. Marshall Building, Ypsilanti, Michigan</u>

This building, home to the Eastern Michigan University's College of Health and Human Services, was designed to be sustainable, versatile, and adaptive to different occupants' varying comfort requirements. Design features to contain and prevent the distribution of chemicals and particulate matter within the building were employed to help maintain high indoor air quality. All building entries have integral walk-off mats to trap dust and particulate matter from shoes before these pollutants can enter the building. Depressurized, full height partitions were used to isolate the air from all chemical storage areas and copy rooms from the rest of the building. Through careful planning, areas for the storage of bio-hazardous waste were located remotely from occupied areas. (Guerin 2004)

Energy Resource Center, Downey California
This building was designed as an example of environmental innovation, illustrating efficient and sustainable design elements. The building houses the offices of the Southern California Gas Company, which wanted to create a working environment for their employees with good indoor air quality that would also serve as an innovative model for others. An intrinsic part of ensuring high air quality is the ability to control and retain chemicals and particulate matter at the source, thereby preventing their wide distribution throughout the building. The ERC's HVAC system maintains positive pressure within the building to deter exterior pollutants from entering. Carpet and other difficult to clean flooring materials were avoided at all building entries to prevent dirt from collecting in the absorbent material and being stirred-up by foot traffic. A robust ventilation system includes both pre-filters and final filters to remove pollutants from the air. The rate of ventilation was designed to exceed ASHRAE Standard 62-1999 to further promote good air quality in this building. (USDOE 2005)

Reference

Definitions

Definitions have not been provided for this Guideline.

Standards

ASHRAE. ANSI/ASHRAE 52.2-1999: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. Atlanta: ASHRAE, 1999.

Bibliography

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U.S. Department of Energy. "Energy Resource Center". Office of Energy Efficiency and Renewable Energy: High Performance Building Case Study. Office of Energy Efficiency and Renewable Energy. 6 January 2005. U.S. Department of Energy. 13 January 2005. <http://www.eere.energy.gov/buildings/highperformance/case_studies/overview.cfm?ProjectID=45>

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Chemical and Particulate Control IEQ-7-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:**
Permanent walk-off grilles are provided at all major entrances

☐ **Required Component:**
Air supply system has been equipped with MERV 13 filters and the owner has been provided with a maintenance schedule for filter replacement

☐ **Required Component:**
All work rooms with printing/copying equipment, janitorial closets, and chemical use areas have been equipped with slab-to-slab partitions, negative air pressure of at least 7PA and an isolated exhaust system of at least 0.5cfm/sf. (All exhausts have been located to prevent re-entrainment of exhaust air to other supply intakes)

☐ **Required Component**
Drains for appropriate disposal of liquid waste have been provided in all spaces where water and chemical concentrate mixing will occur

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Thermal Comfort IEQ-8

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To provide building users with a high level of thermal comfort to promote comfort, well-being, and enhanced productivity.

Action: Design the building envelope to manage the flow of air, moisture and thermal energy in the building. Include capability for adjustments to thermal conditions, seasonal changes and associated modifications in typical levels of clothing to provide indoor thermal comfort conditions selected per ASHRAE Standard 55-2004. Design an integrated system (thermal shell and HVAC) that allows building operators to monitor and control air temperature in each zone. To avoid condensation problems, mechanical systems must be designed to deal with part load cooling conditions so that they are able to maintain appropriate dehumidification levels.

Related Guidelines: EEQ-1, EEQ-3, IEQ-1, IEQ-2, IEQ-4, IEQ-10

Potential LEED™ 2.1 Credits: 2 possible with EQ cr. 7.1 and EQ cr. 7.2. (See Submittal Template)

Introduction/Context

The thermal environment will have an effect on the satisfaction of each person's experience at the site and, for workers, the performance of their work. While critical to the World Trade Center experience, thermal comfort is a subjective feeling, a condition of the mind, which is expressed in terms of personal satisfaction with the thermal environment on the part of each individual. Specific activity levels have an impact on thermal comfort, as well as how individuals are dressed. Air temperature and the temperature of the immediate surroundings, humidity, and speed of airflow in the local environment all modify the manner in which thermal comfort is experienced. Nonetheless, this elusive comfort criterion remains a subjective feeling. Current technology addresses thermal comfort in terms of statistics, predicted mean vote (PMV) of occupants and predicted percent of occupants who are dissatisfied.

In business terms, the challenge is to provide the most comfortable and effective environment based on experience, or a cost/benefit analysis, and to embed flexibility into the building and its systems to enable continuous improvement over time. The following outline scope of Thermal Comfort reflects the breadth of these issues, to include:

- Selection of a 'comfort criteria' suited to the occupancy and business purpose of the space
- Documentation of capability of the building and its systems to deliver the desired comfort conditions under expected load conditions
- Validation of the actual delivery of the desired thermal conditions
- On-going performance tracking and continuous improvement.

Executive Order 111 cites requirements included in NYSGBTC 638.7 (d) Operations and Maintenance Management Plan, and 638.8 Commissioning Requirements related to thermal comfort that include the tracking of thermal comfort complaints, action to address IAQ problems, description of space temperature and humidity criteria, thermal zoning criteria, and controls to be incorporated in the Operation & Management (O&M) Plan, Systems and Energy Management Manual, and the Commissioning Plan, as appropriate.

Relevant Issues

Ecological

The unnecessary swings of heating and cooling energy expended in the pursuit of thermal comfort are yet another category of resource depletion, pollution and global warming that may be associated with poor systems design and operation

Economic

The contribution of thermal conditions to the economic success of the World Trade Center Redevelopment can be described from two perspectives: visitors (or those who are at the site on a temporary basis) and building occupants. Even within a limited timeframe, the thermal environment will color the visitor's perception of their experience at the World Trade Center and their likelihood of a repeat visit.

When it comes to building occupants, the payback potential of contributing to improved work performance is considerable. Since personnel costs dominate the on-going expenditures for operations and maintenance, and even for energy in buildings, it makes enormous economic sense to provide thermal conditions that support the work endeavor. The design team should be aware that in a typical office building, occupant complaints predominantly concern thermal discomfort -- hot and cold calls -- each contributing to overall operation and maintenance costs, and reducing the 'bottom line' through maintenance and reduced productivity.

Neighborhood

Enhanced thermal comfort contributes to worker satisfaction, engendering a more positive social atmosphere in the community. It is also important to recognize and include methods of thermal conditioning that deliver improved thermal comfort while reducing the energy impact. Energy efficiency benefits all members of the community because it reduces pollution and lessens the overall demand for energy.

Methodology

Design Strategies

- Formulate a comfort criteria for space occupant needs and business objectives employing the predicted mean vote model to thermal conditions
- Design building structure and systems to ensure building performance to the comfort criteria, document assumptions, demonstrate performance capability.
- Validate performance in the building commissioning process

- Provide a systematic means for controlling and tracking on-going building performance through an integrated approach of real-time control and measurement of comfort parameters, and occupant surveys.

Means and Methods
Thermal Comfort is an important building life cycle issue. The initial design needs to incorporate expected conditions of operation and use of the building into the specification of the building and its systems. The commissioning process provides a means to validate that the design actually performs as expected. However, the benefits of Thermal Comfort will only be fully realized in the every day use of the building as it and its use evolve with time.

The focus of this chapter is the thermal comfort of occupants as addressed over the life cycle of the building. This includes design specification, compliance documentation, and validation of performance as constructed, as well as the on-going maintenance of the desired conditions.

Determination of Comfort Criteria
Levels of thermal comfort are expressed in statistical terms, the 'Predicted Mean Vote' (PMV) of a group of people experiencing the conditions or the 'Predicted Percentage of Dissatisfied' (PPD) occupants. Levels of comfort can then be described as a lower predicted percentage of dissatisfied occupants.

However, the design of the building and systems requires the specification of physical parameters of a thermal environment. Major factors affecting thermal comfort have been found to include:

- Metabolic rate: occupant activity level
- Clothing insulation: how the occupant is dressed
- Air temperature: temperature of the air around the occupant
- Radiant temperature: temperature of the surfaces around the occupant
- Air speed: regardless of direction, the rate of airflow across the occupant
- Humidity: moisture content of the air around the occupant.

And, sources of local thermal discomfort are related to:

- Radiant temperature asymmetry: exposure to hot or cold surfaces
- Draft: local, unwanted cool air flow
- Vertical air temperature difference: temperature gradient from head to foot
- Floor surface temperature: hot or cold floor
- Temperature changes: cyclical changes, drift, or abrupt, uncontrolled changes

Through research, models have been developed relating these conditions to the expected PMV or PPD of a group of occupants for a given level of activity and clothing. ASHRAE Standard 55 - 2004 provides details of these models and their use in developing comfort criteria. A method is provided for addressing both mechanically conditioned spaces and naturally ventilated spaces.

The term 'comfort criteria' defines a statement of the indoor thermal conditions that are required to maintain desired occupant comfort levels. The criteria are developed for a specific space, a specific set of occupants with specified activity level and clothing insulation. The criteria also identify the range of outdoor environmental conditions, e.g. temperature and humidity under which they are applied. The comfort criteria provide a basis for building and system design.

Design Documentation for Compliance

In the design process, the comfort criteria are applied in an iterative manner, balancing desired performance with associated costs and complexity. For common building types or repeated space types in large buildings, categories may be identified with associated predicted levels of comfort. ISO Standard 7730 provides examples of performance categories applied to office, school, and retail spaces.

During the design process, validation of the capability of the building and its systems can be accomplished by calculations. Documentation of design compliance (ASHRAE Standard 55 - 2004 (6) Compliance), includes:

- Design comfort criteria
- System input/output capacities
- Ability and limitations of system to control building environments
- Identification of space and thermal zones
- Structural and interior elements that may affect comfort
- Areas that lie outside comfort control areas of the building
- Occupant adjustable controls
- Control schematics and sequence of operation
- General maintenance, operation, and performance of the building systems
- Limits in the adjustment of manual controls
- Assumed electrical load for lighting and equipment in occupied spaces.

Validation of Performance – New Buildings

Validating the acceptability of the thermal environment is a component of building commissioning. It demonstrates that the building and systems, as installed, are providing the specified level of performance. Thermal comfort has two methods of specification. It can be specified in terms of the level of comfort (PMV/PPD) to be delivered to each thermal zone, or, in terms of thermal conditions provided relative to the comfort criteria. As a consequence, ASHRAE Standard 55 - 2004 (7.6) provides two methods for validating the thermal environment:

- Survey of Occupants: A survey performed for every operating mode and design condition providing occupant response to the environment and prevailing conditions at the time of the survey.

- Analysis of Environmental Variables: Measurement of thermal conditions per a test plan to demonstrate conformance to the comfort criteria under every operating mode and design condition.

The first method is a direct measurement of occupant satisfaction with the environment. However, it suffers from weaknesses of the survey method of measurement, repeatability, other sources of bias, and perhaps, limited occupant count. The second, measurement of thermal conditions is an objective source of hard data, but it is related to occupant satisfaction only through the models of predicted response. A preferred approach is to incorporate a combination of the two into the Commissioning Plan to gain the advantages of both.

Performance Management for Thermal Comfort
As commissioned, the building offers three types of tools to ensure the continued delivery of the desired level of thermal comfort:

- The Building Management System (BMS) for control, monitoring, alarm, and trending of thermal conditions, both indoor and outdoor
- Measurement and analysis of environmental variables as performed for initial validation; supplement information obtained from the BMS with scheduled measurements
- Occupant survey as a standard practice and on a scheduled basis providing staff and occupant interaction to identify and address sources of discomfort

A systematic means for managing the delivery of thermal comfort to the desired comfort criteria incorporates both technology and process from these tools and is incorporated into the Operations and Maintenance Manual and associated processes.

A further step that may benefit building owner, staff, and occupants is the incorporation of Performance Management for Thermal Comfort into a process for continuous improvement employing a balanced scorecard approach. This will place thermal comfort into a broader business context. There, the benefits of thermal comfort can be leveraged through business objectives to prioritize actions for continuous improvement.

Case Studies

PNC Firstside Center, Pittsburgh, PA

This LEED-NC V.2 Silver Certified office building was designed with an envelope that provides enhanced thermal comfort for its occupants. A hybrid system distributes ventilation air through a plenum located under a raised floor. Occupant-controlled diffusers introduce the air into individual spaces in the building, allowing for greater levels of comfort and enhanced personal satisfaction. Variable air volume units located overhead condition and re-circulate air for additional user comfort. An automated monitoring system adjusts the HVAC system to modulate temperature, humidity, and carbon dioxide levels. The division of the building into 5 distinct conditioning zones further supports the claim that the HVAC system provides adaptive thermal comfort to meet the specific needs of occupants throughout its spaces. (USGBC 2005)

20 River Terrace – The Solaire, New York, NY
This residential tower includes various design features to ensure excellent thermal comfort. Glazing used has a low Solar Heat Gain Coefficient to help prevent the building from overheating during warm months. Although the HVAC system is centralized, a digital control system provides each tenant with a degree of control over the temperature of the air delivered to his or her unit. Each apartment is equipped with operable windows that can be used to provide natural ventilation if and when desired. (AIA 2005)

Reference

Definitions

Thermal Environment refers to the characteristics of the environment (indoor or outdoor) that affect a person's heat loss.

Thermal Comfort is that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation.

Predicted Mean Vote (PMV) is an index that predicts the mean value of the votes of a large group of persons on the seven-point thermal sensation scale:
+3 – Hot, +2 – Warm, +1 – Slightly Warm, 0 – Neutral, -1 – Slightly Cool, -2 – Cool, -3 – Cold

Predicted Percent Dissatisfied (PPD) is an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people as determined from the PMV.

Comfort Criteria is a statement of the indoor thermal conditions that are required to maintain desired occupant comfort levels. The criteria are developed for a specific space, a specific set of occupants with specified activity level and clothing insulation. The criteria also identify the range of outdoor environmental conditions, e.g. temperature and humidity under which they are applied.

Standards

ASHRAE Standard 55-2004 Thermal Environmental Conditions for Human Occupancy

ISO 7730 Ergonomics of the Thermal Environment – Analytical Determination and Interpretation of Thermal Comfort Using Calculation of the PMV and PPD Indices and Local Thermal Comfort

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International Centre for Indoor Environment and Energy website <www.ie.dtu.dk>

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Kats, Gregory H.,. "Green Building Costs and Financial Benefits" Report to California's Sustainable Building Task Force, October 2003
<www.cap-e.com>

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NYSGBTC 638.7 (d) (3) Operations & Maintenance Plan
(includes an IAQ Profile that requires tracking of occupant complaints with further description of walkthrough for problem identification and corrective action to mitigate problems.)

NYSGBTC 638.8 (e & f) Commissioning:
(Design Intent & Basis of Design requires the identification of thermal zoning, control, and 'space temperature and humidity' criteria that are components of the comfort criteria and further require the identification and validation of features and functions of building systems.)

USGBC. "PNC Firstside Center." LEED Certified Project Case Study. USGBC. 13 January 2005. < http://leedcasestudies.usgbc.org/energy.cfm?ProjectID=62>

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Thermal Comfort IEQ-8-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		● Ⓔ	● Ⓔ	●	◉

☐ **Required Component:**
Comfort Criteria determined per ASHRAE Standard 55-2004 Sec. 5 for each thermal zone of the building according to the objective for each space are attached.

☐ **Required Component:**
Design Compliance Documentation is attached as per ASHRAE Std. 55-2004 Section 6

☐ **Required Component:**
Compliance Validation Documentation is attached as per ASHRAE Standard 55-2004 Section 7.6, selecting either the Survey Occupants or Analyze Environmental Variables option
Note: *(The above required components will satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 7.1: Thermal Comfort – Compliance with ASHRAE 55-1992.)*

☐ **Required Component**
A commissioning Plan that incorporates these systems and their features and functions is attached

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 7.2: Thermal Comfort – Permanent Monitoring System.)*
A description of installed control and monitoring system for delivery of comfort conditions included in the Systems & Energy Management Manual and O&M Manual is attached

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Pest Control IEQ-9

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: To mitigate health concerns caused by any unwanted pests, their excrement and the chemicals used to control them.

Action: Develop an Integrated Pest Management Plan based on USEPA Best Management Practices, which promotes physical controls and non-pesticide measures over pesticide application. Physical controls include building sealing strategies, improved sanitation, pest-resistant plantings and improved maintenance of wet areas. When necessary, use boric acid or other nontoxic alternatives in lieu of more toxic chemicals to control and eliminate rodent populations from building.

Related Guidelines: IEQ-1, IEQ-3

Introduction/Context

Pesticide use in and around populated areas and in buildings is, by its nature, a process that must be handled with great care. According to the EPA, "pesticides can cause harm to humans, animals or the environment because they are designed to kill or otherwise affect living organisms." These products often contain lethal substances designed to provide control over insect or rodent populations, and while they are effective in repelling and/or killing such creatures, they can also exacerbate human discomfort and can cause unsafe and even dangerous conditions. (Use of pesticides that are extremely toxic to human beings and domestic animals such as the organophosphate or carbamate insecticides -- malathion, diazinon, and chlorpyrifos, among others -- is rigorously avoided in a sustainable Integrated Pest Management (IPM) program. Generally, use of such poisons is replaced by a program which relies on good planning strategies to minimize pest access, strictly enforced sanitation strategies, biological and mechanical pest control measures and, as a last resort where necessary, the use of low-impact, safer chemicals).

It is practically impossible to totally eliminate unwanted pests in urban settings. The objective of an Integrated Pest Management Plan (IPM) is to minimize these populations in and around buildings, thereby reducing the potential health risks associated with them, their dander and excrement, and eliminating the damage they can do to the fabric of the building and its finishes. The IPM must clearly define the means and methods by which to monitor and control pest populations. It will identify a Pest Management Professional (PMP) who will conduct inspections during construction and establish a series of steps intended to inhibit pest access to the building through physical measures, efforts to eliminate conditions which would support and feed pest colonies, sanitation measures, and maintenance strategies for wet areas, landscape areas and open spaces around the building. The work of separate project PMP's will be more effective if it can be coordinated with all other site IPM plans. As a further strategy when necessary, the plan will discuss the appropriateness of a low-toxic chemical application program, targeted to specific pest populations, and which has minimal effect on the safety and well-being of building occupants and domestic animals.

There are several varieties of pests found in most New York buildings in urban settings. Typically these include rodents, such as mice and rats, and insects, such as cockroaches and occasionally ants, silverfish, spiders and fleas. Fruit flies may invade kitchen and cafeteria areas. Moths can infest areas with untreated wool carpets or upholstery. Outdoors, most of the agricultural pests such as ticks and Japanese beetle (*Scarabaeidae*) are absent in urban locations. However, some outdoor pest populations thrive in the city and must be addressed in the plan. Weeds are considered to be pests and are often controlled with highly toxic herbicides, while water in cooling towers, swimming pools, fountains and reflecting pools must be treated to control the growth of water-borne microorganisms.

Fungi and microorganisms including bacteria and viruses are also termed 'pests' and may have serious impacts on indoor air quality and human well-being; however mitigation of such conditions, which can lead to sick building syndrome (SBS) is generally handled in a different manner – see IEQ-05.

Relevant Issues

Ecological

Health Risks of Traditional Pesticide Applications
Typical pest management systems, which employ effective but highly toxic chemicals have been used in recent years to control unwanted pest populations. However, because of their basically poisonous composition (they are designed to kill), they themselves often pose additional health risks for human beings and domestic animals. The risks from traditional pesticide treatments range from inadvertent skin contact with the chemicals, adverse respiratory reaction to airborne toxins and VOCs, and contamination of food exposed to pesticide spray applications, to the small but serious potential for young children and/or pets to actually eat substances such as rat poison. Unpleasant odors and indoor air contamination emitted from the chemicals themselves, and occasionally from dead or dying rodents that have ingested the control substances, and may be in concealed or inaccessible locations, are a further cause for concern.

Vertebrate Pests
Vertebrate pests such as rodents carry disease – the best known example is, of course, the Bubonic plague (Black Death), which, in the Middle Ages, was carried to Europe by shipboard rats and spread by a combination of these animals and their parasitic fleas. Rats and mice are also known to act as intermediary hosts in the transference of several other serious illnesses. They can contaminate food left uncovered in kitchens and pantries, and easily access poorly sealed food supplies, resulting in occasional outbreaks of Salmonella. Mice carry the deadly Hantavirus as well as Lyme disease, while other diseases spread by both rodents include dysentery, foot and mouth disease, swine fever, Chagas' disease, Rocky Mountain spotted fever and trichinosis, to mention only a few. In addition as noted, rats and mice can be the source of fleas in occupied buildings.

Rats cause destruction to the building fabric, gnawing through wood, wallboard, plastic, nylon mesh, and even concrete panels to gain access, and to maintain the sharpness of their teeth, which grow throughout their nine-month lifespan and must be constantly worn down. Both rats and mice gain access to buildings through pipes and sewers, drains, cracks in the building, pipe openings, loading docks and doors. They climb up rough masonry, and nearby bushes and wires, gaining access through air grilles, vents and windows. Once inside, they can travel everywhere via the buildings' concealed, integral system of pipes and ductwork. With access to food and water, they begin to reproduce at an alarming rate.

Insects

Insect infestations in New York are primarily of cockroaches. There are four common species in the city -- the American, the German, the brown-banded and the oriental cockroach. All are nocturnal, living in large colonies in dark, warm and preferably moist locations. They eat anything and everything organic and they need water, though not in great quantities or even frequently. They are dirty and carry bacteria. Their droppings and dry, powdery exoskeletons become airborne and are a known source of respiratory illness, breathing difficulties and asthmatic reactions. Cockroaches are ubiquitous, enduring and practically impossible to eradicate; however cockroach populations can be controlled so that they are less problematic in buildings.

Cockroach detritus contributes to respiratory disease in children and adults. "Research has shown (the) cockroach as the most significant allergen in children and adults with asthma. However, there is very little known about asthma and the elderly. This study suggests that (the) cockroach is a highly significant allergen to all age groups." *(Source: Linda Rogers, M.D., assistant professor, medicine, New York University School of Medicine, and attending physician, Bellevue Hospital Asthma Clinic, both in New York City)*

Where wool carpeting is used -- a preferred environmental option when treated and maintained correctly -- moths may be a problem in New York City. Most imported wool, including the typical Wools of New Zealand brand carpet wool, must be treated with moth-resistant chemicals prior to entering the United States. However, with repeated wet shampooing, some moth-resistant chemicals wash out, and the floor covering becomes vulnerable to infestations of these insects, which are extremely difficult to eliminate. Moths tend to prefer dark, undisturbed spaces, under furniture and at the baseboard, where their damage may not be immediately apparent, giving the colony time to gain a strong foothold. Once established, they lay eggs, larvae hatch, and the carpet may well be destroyed before the infestation is caught and treated.

Although there are many other pests that may be encountered in and around the World Trade Center site, those noted above are the principal ones that will, most likely, have to be managed under the IPM plan.

Economic

Uncontrolled infestations of pests are unattractive and can cause both psychological and physical damage. There is a high cost associated with the management of an infestation of moths, for instance, where, once established in a wool carpet, the only solution is to replace the entire floor covering. Similarly, large colonies of cockroaches are difficult, and expensive to remove. However, a much greater cost occurs when building occupants become seriously ill, either from exposure to pest detritus, or from the chemicals typically used to control pests.

Investing in an Integrated Pest Management system (IPM) in an urban setting like the World Trade Center redevelopment in New York City, which is close to the port, is generally a smart move. Large projects are well advised to engage the services of a PMP, however, smaller projects may want to invest in a shared plan for the support of a pest management professional (PMP) or pest manager. In either case, it will be money well spent, both during the building planning, and following occupancy.

Neighborhood

Nothing is less attractive and more 'off-putting' than the sight of rats and/or cockroaches scurrying about around the base of a building! The presence of multiple numbers of these creatures blights the entire neighborhood, and suggests that the area is unkempt, dangerous and dirty. The psychological impact is far greater than the unpleasant reality of the rodents and/or bugs. A well conceived Integrated Pest Management Plan can minimize the presence of rats, mice, cockroaches, water-bugs and moths, etc., while causing little danger to the building occupants.

Through the use of planning techniques to minimize pest access to the building(s), and careful methodologies designed to deprive them of a means of survival (food and water) once they do gain access, pest populations can be controlled. It benefits the neighborhood to be as free as possible of these vermin, but only when they are controlled in such a way that the local population is not exposed to further danger; i.e. through the application of an established, low-toxicity IPM plan.

Methodology

Design Strategies

Integrated Pest Management is an environmentally safer, but still effective way to manage and reduce pest populations. It was originally developed for agricultural and urban pest management, and encourages preventative measures and the use of the least dangerous approach to eliminating, or totally eradicating pests commonly found in buildings and their immediate surroundings. Implementing and managing the on-going requirements of an IPM plan requires a full understanding of the nature of each pest, its life-cycle and habits, and the conditions that support its ability to gain access and thrive in the building. The objective is to make 'the site' inhospitable to each type of pest, through the elimination of those conditions.

The IPM plan must include the selection of a person or group who will be responsible for overseeing and managing all parts of the program. An experienced PMP needs to be engaged early in the design phases of the project in order to flesh out the plan, and to work with the architectural team on design issues relative to limiting typical means of access for rats, mice and insects to the project. The main job of the PMP will be to design a specific approach for managing all types of anticipated vermin and insect populations during design, construction and occupancy of the building on an on-going basis.

Means and Methods
The Pest Management professional could be an employee of the owner or tenant; however it is recommended that a licensed Pest Management Professional (PMP) be selected, as these professionals have the training, skills, resources, equipment and knowledge to design and administer such a program. Most IPM plans are broken down into three distinct but connected areas of responsibility, expertise and implementation, as follows:

- The first step of the IPM program involves strategies to design maximum physical barriers for access for rodents, etc., and is the responsibility of the architectural team working under the guidance of the PMP.
- The second area of responsibility occurs during construction and involves constant inspection of the work. The architectural team, the contractor or CM and the PMP undertake this part together.
- The third establishes the process for the on-going administration and implementation of the program. This is the area of expertise of the PMP and their agents who will need to have a continuing, ever-vigilant role if the project is to remain free, or reasonably free, of pest populations. The PMP will work with assigned building personnel to accomplish this on-going work.

Once the IPM plan outlining the hierarchy of responsibility is established, the team must look for means to prevent pest access to the building as the work proceeds. This can involve limiting vulnerable access points in the basement and ground floor, sealing all holes and cracks, quickly repairing broken pipes and covering all pipe openings, vents and drains with steel mesh, grilles or sheet metal – whichever is most appropriate.

Trees and shrubs must not be planted so close to the building that they brush up against or lean on it, providing concealment, and a method for rodents and insects to elevate themselves to more accessible openings such as windows and vents. Likewise, pipes, wires or conduits against the exterior building walls provide an easy means of access for vermin.

Garbage and recycling areas are particularly vulnerable to pests and must be maintained to a very high degree in order to eliminate unpleasant conditions arising. Ensure during the layout of these areas that they are not close to a building access point, such as the loading dock. Meticulously avoid mixing biodegradable (food) waste with other materials and keep biodegradable materials tightly covered in steel containers, preferably raised off the floor or ground. It is important to be able to clean these areas properly. Provide a wash-down system or an outdoor hose near the garbage and recycling collection areas. An electrical outlet is also appropriate to assist with the use of power cleaning machines.

Inside the building, maintain rigorous requirements for the disposal of food waste, and leave no food uncovered in the kitchens, pantries, break-rooms or dining rooms.

Clean up spills immediately and repair broken pipes, faucets and/or leaks as soon as they occur.

Case Studies

Vermont School IPM, The University of Vermont Extension

A team at the University of Vermont Extension have drafted a sample Integrated Pest Management Plan to be employed at all public schools in the state. Although this plan is intended to be enacted for existing buildings and does not discuss new construction design features for pest control, it does cover how building operations staff can safely and effectively cope with pest problems in an occupied building. The goal of the plan is to prevent unnecessary exposure of building occupants to pesticides by reducing the need to rely on these chemicals for pest management. As part of this, this plan prohibits the preventative use of pest control chemicals. Instead it encourages benign preventative measures such as good sanitation practices and maintenance. In the event of infestation, the plan promotes non-chemical measures such as non-pesticide traps. In cases where the problem is so extreme that pesticides are the only recourse, the plan outlines specific safety protocols that should be used to ensure protection of building occupants. (UVM Extension 2005)

Reference

Definitions

Vermin any of various small animals or insects that are pests; e.g. cockroaches or rats.

Standards

No standards have been included for this Guideline.

Bibliography

The University of Vermont Extension. “Sample School Integrated Pest Management Plan”. University of Vermont. 13 January 2005. <http://pss.uvm.edu/pd/schoolipm/documents/sampleplan.doc>

Objectives

Develop an Integrated Pest Management Plan (IPM), based on USEPA Best Management Practices, which promotes physical controls and non-pesticide measures over pesticide application.

Physical controls include building sealing strategies, improved sanitation, food storage and biodegradable waste management strategies and improved maintenance of wet areas. When necessary, use traps, boric acid or other nontoxic alternatives in lieu of more toxic chemicals to control and eliminate rodent and insect populations from building.

Plan Components

I. Project Description (Plan Summary)

A. Physical description of project
B. Physical description of neighborhood
C. Identification of the PMP
D. Requirements of the IPM to be established between the owner, architect, contractor and PMP.
E. Summary of steps proposed to implement the IMP
F. Responsibilities of each party to accomplish the IMP.

II. Pest Inventory

Provide a detailed list of known and anticipated pests at the site and in the area. Organize the plan according to strategies targeted at managing vertebrate and insect populations, and include a section on the management of exterior areas, if and where appropriate, to address insects, weeds and unwanted, invasive plants.

III. Management Strategies

A. IPM Pre-Construction Preventive Measures
   1. Identify and engage a PMP
   2. On the building floor plans – below grade and ground floors, identify vulnerable access points, and locations that must be properly sealed during construction.
   3. Identify methods and materials for sealing holes and cracks such as concrete or similar fillers, sheet metal, steel mesh and grilles.
   4. Indicate methods for protecting access doors, vents, etc.
   5. Indicate all drains and pipe openings where metal grilles will be used to prevent rodent access.

6. On the plan drawings, indicate setbacks for shrubs and trees relative to the building façade where operable windows, vents and grilles could potentially allow access.
7. Indicate location for staging of garbage and/or dumpsters and ensure that they are not near or directly under any potential access point.
8. Indicate the location of a hose bib for washing down garbage staging area.
9. Indicate the location an exterior outlet for use of electrical equipment in cleaning the staging area.

B. IPM Plan -- Measures to be Adopted During Construction:

1. Indicate approaches to maintaining clean premises at all times. Include instructions to contractor requiring separation of leftover food and biodegradable materials (sandwiches, paper wrappers, cartons, etc. from construction workers on-site meals, etc.) to prevent commingling this waste with construction debris. Require provision of special steel waste receptacles with lids for these materials. Waste receptacles, identified for this purpose, must be clearly marked in English and Spanish.
2. The Plan will establish a schedule of inspections by the PMP to make sure that the strategies and precautions outlined under IPM Pre-Construction Preventive Measures (above) are being completed satisfactorily.
3. Indicate required inspections of all areas where service pipes, etc. enter the building and waste pipes exit the building to confirm tightness of seals at points of entry and exit.
4. Indicate required inspections of all wet locations (rest rooms, janitors' closets, kitchens, pantries, maintenance and service areas, etc) to confirm tightness of pipe-fittings and all holes, voids, cracks or similar are properly stopped.
5. The Plan will include visual inspections of vulnerable pipes and locations where water leaks could occur inside the building.
6. Indicate that spills and standing water or puddles must be cleaned or mopped-up promptly.
7. Indicate that drains and open pipes are required to be covered with grilles.
8. Note that temporary or loose cabling, or wires on the exterior of the building that can act as a means for rodents etc. to gain access to higher entry points will not be permitted.
9. The Plan will allocate space for stock-piling materials. Stacking materials against the building where they can act to conceal the presence of rodents and vermin, potentially allowing them access to the building from concealed locations, will not be permitted.

C. IPM Plan -- On-Going Monitoring:

1. A schedule of inspections of all potential points of entry for rodents will be included.
2. Outline approaches for the monitoring of pest populations on a continuous basis.

3. Outline an occupant-response plan to immediately address complaints concerning the presence of pests (occupants are usually the first to notice cockroaches, mice and rats).
4. Indicate an action threshold point at which pest control action must occur.
5. Outline a set of guidelines which establish good sanitation rules so that absolutely no foodstuffs are left exposed in kitchens, pantries and storerooms.
6. Outline a set of 'good house-keeping' standards that require the removal of areas of standing water and immediate clean up of spills, leaks, etc. that could be a source of water for vermin.

IV. Targets

The overall objective of this plan is to prevent pest colonies from establishing themselves and thriving in the World Trade Center buildings. However, in New York City, especially near the Hudson River and the port, it is almost impossible to totally eliminate vermin. The effort is therefore focused on severely limiting the presence of rats, mice, cockroaches and other vermin in the World Trade Center buildings. The greatest potential to achieving this goal is to create a completely inhospitable environment that does not support the basic requirements necessary for the livelihood of these vermin. By removing all casual food and water sources, large rat and mice populations will be unable to thrive, and insects such as cockroaches, will also be controlled. In order to achieve this goal, food service personnel, as well as building occupants, will need to be instructed in the specific handling of food and biodegradable waste.

The second target is to use a vermin control plan that is effective while avoiding the use of chemicals such as pesticides and rat poison, which are harmful to building occupants and domestic animals. Along with denying food and water sources to vermin, minimizing easy access and immediately addressing 'first signs' of their presence, via non-toxic means, will also contribute greatly to the effectiveness of these strategies and to reducing numbers. Careful implementation and follow through on the IPM plan will achieve this goal.

V. Evaluation

Complete a report at the end of construction that describes strategies established to minimize pest access to the building. Indicate where the plan has been established successfully and where there are vulnerabilities such as at the loading dock, which may need specific, vigilant observation during the on-going implementation of the IPM plan. Indicate measures established to educate and inform food service personnel and building occupants on the proper handling of food waste to reduce the potential for pests in the building.

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Pest Control

IEQ-9-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED[TM] Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●	●	●	●
		Ⓔ	Ⓔ		

☐ **Required Component:**
A copy of an Integrated Pest Management Plan based on USEPA Best Management Practices to promote physical controls and non-pesticide measures over pesticide application, is attached.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Purpose: To provide building occupants with a high level of thermal, ventilation, and lighting system control to promote productivity, comfort and well-being.

Action: Provide building occupants with individual controls over airflow, temperature and lighting systems. Provide operable windows where practicable and feasible.

Introduction/Context

The World Trade Center Redevelopment will include a rail station, hotels, performing arts center and other entertainment venues, as well as office towers, underground malls, street level shops, restaurants and cafes. With 10 million square feet of office space and 880,000 square feet of retail space, it will be a workplace for tens of thousands of people. The concept of design excellence envisions a community that is structurally, economically, and politically sound, providing a user-friendly and attractive atmosphere for workers, residents, visitors and tourists.

With a focus on the workplace, the principle is an environment that connects at a very human level to the workers, individually and in work teams that power business success. The human story of the World Trade Center is compelling, like no other. It is grand and terrifying and basic. It is about a workplace functioning in both normal and emergency modes, and the astonishing heights determination, grit and city pride can engender out of the despair that characterized this site, and its people, just a few years ago.

How buildings and their systems help people perform their normal tasks and achieve their objectives is a basic element of design excellence. Enabling building occupants to control their local environment has been shown to contribute to high levels of productivity and to a sense of well-being. The provision of individual access to local controls for lighting, temperature and ventilation is not always an easy task. But, the potential payback in workplace productivity of only a few percentage points dominates all other sources of green building savings and certainly supports full investigation of the opportunity.

While Executive Order 111 does not directly cite local control, there are several related issues raised in NYSBGTC 638.7 (d) Indoor Air Quality. The IAQ Profile requires a record of occupant thermal comfort complaints and procedures for responding to, and mitigating, the cause. In the NYSGBTC, Section 638.8 (e) Commissioning Design Intent and Basis, a narrative describing the level of occupant control over HVAC is required to be provided. The support documentation cited for this guideline is intended to be an integral component of the Design Intent and Basis narrative. LEED NC v 2.1 EQ Credit 6 requires further calculation related to floor area, location, and provision of lighting, temperature and ventilation control and operable windows.

Relevant Issues

Ecological

Personal control can contribute to environmental impact in two ways; on one hand enhancing value; and on another, lowering environmental impact of the World Trade Center Redevelopment. Personal control of workplace environment has been associated with productivity improvement. For a nominal increase in the expenditure of natural resources, significantly greater value is created by the business enterprise that provides its workers with a more productive work environment. That enterprise may be a better investment of natural and human capital.

Personal control allows the individual or local team to adjust their work environment to meet the specific needs of their current task. The nature of their work, their sense of comfort and well-being, as well as local conditions, change over the work day. If enabled by local controls for lighting, ventilation and temperature, individuals can adjust their environment to suit their current need rather than accept a code-level standard delivered under all conditions, which may be designed in part to manage and lower energy use. Of course, if accumulated choices are intended to result in lower energy use, building occupants need to be empowered with this knowledge of the impact of their decisions in order to be active participants in improving management's goals. Typically, the incremental increase in energy use associated with providing employees with the means to control their comfort level, is quickly off-set by acknowledged satisfaction with the workspace, and resulting increases in productivity.

Economic

As formulated for a balanced scorecard approach to building performance, measures of workplace performance include elements of cost reduction and value creation, such as: profitability, capacity for innovation, quality of work life, employee retention, operational efficiency and others. While all of these elements can be measured, metrics are not often readily available and the causal link to those conditions that contribute to them is difficult to establish.

The basic principle is that people will work better individually and in teams if they are empowered to adjust the environmental parameters. The research to-date seems to confirm that principle. One attempt to place specific numbers on the gains in productivity realized has the average measured workforce productivity gains of 7.1% with lighting control, 1.8% with ventilation control, and 1.2% with thermal control. Taken across the operations of a business, the potential economic gain associated with these improvements is very attractive (Overall Productivity and Health Benefits of Green Buildings were estimated at $36.90 to $55.30 per square foot). Their application requires assessment of the specific business and its operations *(Kats 2003).*

Neighborhood

Underlying the goals and objectives for the WTC Redevelopment is the success of business enterprises located there. As a center of economic activity, the quality of its workplaces and its productive work environments will support business success and promote further development of Lower Manhattan. Further, a workplace known for its contribution to individual and team success will support a strong sense of community in building occupants. That feeling of well-being can easily transfer to customers and members of the surrounding community, generating benefits well beyond the confines of the office or workplace.

Methodology

Design Strategies

- Embed personal control of local work environments in a whole-building approach to indoor environmental quality, particularly as related to lighting, ventilation and temperature.
- Identify control opportunities that can be effectively implemented in individual workspace areas and those available in team workspaces, e.g. multi-occupant offices, conference rooms, classrooms, or open team area.

Means and Methods

Personal Control of the local environment is about work performance as it is affected by both local environmental conditions that can be adjusted to meet personnel needs and worker motivation derived from being in control of local conditions. Appropriate applications for consideration of Personal Control devices include both individual and team or multi-occupant workspaces. Spaces for which the benefits of Personal Control do not apply include those that are not regularly occupied for work-related purposes, such as corridors, lobbies, storage rooms, rest rooms, local copy rooms, local kitchen areas and the like.

Personal Control has value only related to its impact on the workforce. A direct measure of its implementation is the percent of the total workforce empowered with Personal Control at their workstation, coupled with the percent of other team workspaces enabled for local control. LEED NC v2.1 EQ Credit 6, Systems Control, includes a calculation related to floor area as a means to quantify the extent of implementation of Personal Control. It provides an indirect indication of the percent of the total workforce that is empowered with Personal Control. When this LEED credit is sought, design teams should run the calculation to determine compliance.

Leveraging the synergies of 'best practice green building design' is especially critical to the cost-effective implementation of Personal Control. The typical workspace is integrated into the whole building design, where this approach is appropriate in considering localized control of lighting, temperature and ventilation. Related Guides include: IEQ – 12 Lighting Quality, IEQ – 8 Thermal Comfort, IEQ – 4 Ventilation Air Quality, and EEQ – 3 Optimize Energy Performance. Personal Control may present opportunities to lower energy use or possibly generate an increase in energy use. An integrated approach is required that includes enabling the occupant to perform their role in maintaining good indoor air quality by educating them to use their personal control options for their personal comfort.

<u>Lighting</u>

A quality lighting environment is the result of an integrated approach incorporating day-lighting and electrical lighting, ambient lighting appropriate to space use, task lighting per specific task needs, and other lighting quality parameters. Guideline IEQ – 12 Lighting Quality describes the whole building approach to design of a quality lighting environment. The strategy here is to embed Personal Control into that design.

People have differing preferences for illuminance, the nature of tasks they perform varies in the course of a work day, and the location in which they perform them may change. Personal Control of lighting can be as simple as an on/off control of a local task light that could be moved to suit the individual's need or an on/off control of a bank of lights in a team room to suit the current team task. Dimming control has been found to be particularly effective when applied to task lighting or overhead fixtures with direct and indirect lighting components. In teaming or multi-occupant workspaces, provision of local adjustment of lighting enables modifications to a number of desired lighting condition to be made.

Temperature & Ventilation

A quality thermal and ventilation environment is also the result of an integrated approach to building structure and building systems design. The strategy is again, to embed Personal Control into these components of building design.

'Ventilation' as applied here to Personal Control requires further explanation. Ventilation for acceptable indoor air quality per ASHRAE Standard 62 – 2001 is defined as "the process of supplying air to, or removing air from, a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space." As related to Personal Control, ventilation may indeed involve supplying or removing air from the local space, but the purpose is to allow the occupant to adjust comfort conditions to suit their personal or team needs. The amount of outdoor air introduced to control contaminant levels or humidity is a separate issue, however, temperature too, is a factor of comfort. In the case of naturally ventilated spaces through operable windows, ventilation and thermal comfort control are the same.

The primary factors affecting thermal comfort (ASHRAE Standard 55 – 2004) are:

- Metabolic rate: occupant activity level
- Clothing insulation: what the occupant is wearing
- Air temperature: temperature of the air around the occupant
- Radiant temperature: temperature of the surfaces around the occupant
- Air speed: regardless of direction the rate of air flow across the occupant
- Humidity: moisture content of the air around the occupant.

The first two of these are determined by the occupant and the schedule of activities. Personal Control typically enables the occupant to adjust the remaining four conditions over some limited, but effective range: air temperature, some component of radiant temperature, or the amount, speed, or direction of air flow in their local area.

Thermal comfort is a subjective feeling. People respond differently to thermal conditions, their activities may change throughout the work day, and clothing may be seasonal. Personal Control of one or more of the thermal factors affecting comfort enables the individual or team in a multi-occupant space to adapt their environment to better suit their individual preferences as they change over time. The regimen of Personal Control is an integral component of the comfort criteria (see IEQ – 8) for the related workspace and its design should reflect the overall intent used in developing the comfort criteria.

<u>Mechanical Systems</u>
Personal Control as implemented in mechanically conditioned and ventilated spaces may take a variety of forms. It may be local temperature control provided in an enclosed office, small laboratory, conference room, or classroom. Or, it could be local control of air flow, including, speed, amount, or direction of air flow delivered to an individual workstation from an under floor distribution system. Radiant panels also provide a means for local adjustment of the thermal environment that could be integrated into the overall thermal comfort design.

<u>Operable Windows</u>
Operable windows employed as a component for natural ventilation have a specific definition in ASHRAE 62 – 2001. The window opening is required to be a minimum of 4% of the net occupiable floor area of the naturally ventilated space, and that space must be permanently open to and within 25 feet of the window. It has been found that with operable windows, people feel comfortable over a broader range of temperatures that varies with the mean monthly outdoor air temperature (refer to ASHRAE Standard 55 – 2004).

Personal Control through the use of operable windows in a naturally ventilated space has a more limited range of applications in New York City than it might in San Francisco or Seattle. However, the seasonal variation in New York City presents those days when natural ventilation would be a delight. Knowing that, in the case of a noxious spill or other air quality accident, natural ventilation is at hand is a great personal reassurance and value.

Case Studies
<u>West Bend Mutual Insurance, West Bend, WI</u>
When the West Bend Mutual Insurance Company had their new headquarters designed and built in 1991, one major goal was to create a working environment that would provide superior comfort for employees while also being energy and cost efficient. In order to give occupants the ability to adjust their work area to suit their own varying thermal comfort needs the design team decided to use Environmentally Responsive Workstations (ERW's) produced by Johnson Controls Systems. Even in an open office plan, these desk-top integrated units allow individual employees to control the temperature and flow rate of their own personal desktop air register. To further enhance thermal comfort control, a radiant heating panel is located under the desk to warm the lower body. Employees can also control their own level of task lighting and use a white-noise generating device to block-out distractions. The effectiveness of this system was evaluated by an independent worker productivity study conducted by the Center for Architectural Research at Rensselaer Polytechnic Institute. The results of this research showed a 16% productivity increase in West

Bend's employees after they moved from their previous offices to the new building. By partially disabling the ERW's and noting a 13% decrease in productivity, it was determined that the enhanced personal control afforded to the workers was responsible for a 2.8% increase in their production. According to West Bend Mutual, that translated to an annual projected annual savings of $364,000 on a 13 million dollar payroll. (Kroner 1992)

Reference

Definitions

Individual Workspaces are those regularly occupied work areas that support a single worker such as an office cubicle in an open office plan, a single person office, or special work station supporting a single person such as a call center service provider, lab technician, or receptionist.

Team Workspaces or Multi-occupant Workspaces are those regularly used work areas that support a more than one worker such as a multi-occupant office, conference room, classroom, or open team area in which control of the local environment is a shared action that supports local team development.

Personal Control is the ability to manipulate environmental systems to adjust for local needs. It may be switched or variable control of quantity or direction of the controlled parameter e.g. on/off or dimming control of task lighting, adjustment of air temperature, local quantity delivered, or direction of air flow.

Naturally conditioned spaces, occupant controlled are those spaces where the thermal conditions of the space are regulated primarily by the opening and closing of windows by the occupants.

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.

Standards

IESNA 9th Edition Handbook, Chapter 10 Quality of the Visual Environment

ASHRAE Standard 62-2001 Ventilation for Acceptable Indoor Air Quality

ASHRAE Standard 55 2004 Thermal Environmental Conditions for Human Occupancy

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Personal Control — IEQ-10-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	○	○
		Ⓔ	Ⓔ		

☐ **Required Component:**
A narrative is attached describing the level of occupant control over their local workspace environment, including individual workspace and shared multi-occupant spaces such as conference rooms, classrooms, or open retail areas. Environmental parameters to be considered include lighting, and temperature and ventilation control via mechanical systems or, temperature and ventilation control via operable windows where operable windows may present a feasible alternative.

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 6.1: Controllability of Systems – Perimeter Spaces.)*
This certifies that regularly occupied perimeter spaces of the building have at least one operable window as defined by ASHRAE 62-2001 and one lighting control zone for every 200 square feet (on average).

☐ **Optional Component:** *(To satisfy the requirements of LEED™ 2.1 Indoor Environmental Quality Credit 6.2: Controllability of Systems – Non-Perimeter Spaces.)*
This certifies that a minimum of 50% of building occupants in regularly occupied, non-perimeter areas have been provided with control over individual airflow, temperature, and lighting.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Acoustics IEQ-11

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Purpose: Minimize vibration and noise levels in indoor spaces and at exterior environments to achieve appropriate physical comfort and sound isolation for tasks and speech intelligibility, while contributing to human well-being and productivity.

Action: Where practical, program locations of mechanical equipment and other sources of noise away from areas of building and exterior spaces designed for use by building tenants and the public. Design separations to minimize transfer of noise. Consider strategies to reduce the transmission of exterior ambient noise. Comply with the recommendations of ASHRAE Applications Chapter 47 Design Guidelines to reduce potential noise and vibration from mechanical equipment, and the Architectural Graphic Standards 8th Edition: Sound Isolation Criteria Table, page 44, to address acoustic criteria for enclosed office space such as offices, meeting rooms and other occupied areas.

Related Guidelines: SEQ-5

Introduction/Context

In 2003 alone, New York City received over 11,000 noise complaints. Many of these complaints were focused on street noise, including demolition and construction work, street reconstruction and resurfacing, vehicular traffic, car horns, etc. Other complaints relate to building mechanical systems, which are too loud or lack noise control features.

Many office and residential environments are noisy as a result of poor planning and design, intrusive noise from nearby mechanical equipment, lack of absorptive materials and insufficient speech privacy or sound isolation.

Aggravating noise levels, either because of excessive decibel levels or because of their repetitiveness or annoying character, are known to adversely affect human health and well-being. People require periods of calm and quiet each day in order to function at their optimum levels. It is well documented that prolonged exposure to noise over 85 dB causes permanent hearing disabilities, and can result in the development of serious medical conditions, including hypertension and heart disease. Intrusive noises, even at low decibel levels, can impair performance, interfere with concentration and reduce attentiveness, memory skills and the ability to focus.

In the city, with its many sound reflecting surfaces, large amount of vehicular traffic, on-going demolition, construction and road-building and all of the associated mechanical and transportation equipment, ambient street noise is frequently raised to uncomfortable and sometimes unhealthy levels. For this reason, indoor environment noise management is essential.

Building design needs to take into consideration potential noise pollution and build-in strategies to reduce, manage and prevent conditions that may lead to the excessive transfer of sound, both within and from outside the building.

Relevant Issues

Ecological

Excess or disruptive noise levels create health concerns for people. Prolonged noise exposure is known to contribute to stress-related ailments, while sudden, loud sounds can both frighten and distract people, reducing concentration and productivity and occasionally, causing accidents. Outdoors, excessive noise is disruptive to natural ecosystems, adversely affecting wildlife, such as songbirds.

Economic

Work environments with low levels of distraction encourage concentration and are central to the success of productive workplaces. Employees are distracted in quiet environments where occupant or exterior activity is intrusive, resulting in broken concentration and less productivity. Pleasant workplaces, which are designed with appropriate level of sound absorbing materials, suitable sound blocking construction techniques, and speech privacy systems (also referred to as ‘sound masking or ‘white noise’) help to reduce the intrusiveness of non-associated activity noise and in turn, increase employee satisfaction. This has been related to a reduction in absenteeism and higher worker performance. Prospective tenants are likely to be positively influenced by a space that is isolated from exterior noise, and to rent spaces where ambient noise is not a distracting or potentially disruptive factor.

Neighborhood

From time to time, all city neighborhoods are subjected to an uncomfortable level of noise – during the demolition and/or construction of nearby buildings, road repair and from the frequent noise of loud vehicles. The objective is to minimize the resulting disturbances so that periods of disruption are brief, and the noise is muffled to some degree so it is not perceived as on-going. Impact noise levels from vertically stacked spaces can be minimized through the selection and incorporation of sound and impact isolating floor/ceiling constructions. Importance is also placed on providing residences where sleep disturbance from interior and exterior activity is minimized. Neighborhoods that offer peaceful, quiet environments are more attractive than consistently ‘loud’ areas, and tend to be more beneficial psychologically, physically, socially and environmentally to their constituents. Noise pollution discourages community interaction, ultimately driving people away from a neighborhood.

Office buildings that are well designed can minimize the noise and vibration associated with mechanical equipment and exterior activities. Indoor environments can support speech privacy, while reducing reverberation through the use of sound absorbing materials.

Methodology

Design Strategies - Room Acoustics

A room with good acoustics enhances speech intelligibility and minimizes the build up of noise. For good speech intelligibility a Rapid Assessment Speech Transmission Index (RASTI) of 0.60 or higher is recommended (0.60 to 0.75 - “GOOD”; 0.75 and above - “EXCELLENT”).

To control the build up of noise for spaces that require good speech intelligibility, the following reverberation times are recommended:

Room Volume (cu.ft.)	Reverberation Time (sec.)
less than 2,000	0.5
2,000 to 4,000	0.6
4,000 to 8,000	0.7
8,000 to 16,000	0.8
16,000 to 32,000	0.9
32,000 and greater	1.0 *

* Auditoria for music performance should be designed for reverberation times that are consistent with the type of music intended. An acoustical expert should be consulted for this goal.

For atria, which are used as locations for lectures, functions or gatherings, the design should incorporate sufficient sound absorbing materials to achieve an average sound absorption coefficient of all surfaces of 0.18 or greater.

<u>Design Strategies - Speech Privacy and Sound & Impact Isolation</u>
Spaces designed with good speech privacy and appropriate sound isolation can provide freedom from distraction for workers, minimize the transmission of confidential speech, limit the transfer of sound across demising constructions and reduce the intrusiveness of exterior noise.

For spaces that are enclosed with solid partions, the sound isolating performance of the construction should be consistent with the program of the space. Select construction materials that have a sound isolation performance level consistent with the minimum levels noted in the Sound Isolation Criteria table in the latest edition of the Architectural Graphic Standards (page 61 of the 9th Ed.). This is important for spaces such as offices, meeting rooms, residences, mechanical rooms, and spaces with noise sensitive programs.

For vertically stacked residential and office spaces, the floor/ceiling construction should be selected to be consistent with local code requirements, and with a floor/ceiling assembly resistance to the transmission of impact noise of no less than an impact isolation class of fifty (IIC 50) for occupied spaces. Vertically stacked residences that are intended for above market rates shall have constructions with IIC ratings of 60 or higher.

For open plan office spaces, the design shall include elements that provide suitable levels of sound privacy for the workers. The tenant shall select performance goals according to the following levels of privacy:

Desired Privacy Level	Articulation Index
Confidential (audible but non intelligible)	0.05 or lower
Normal (audible and partially intelligible)	0.05 to 0.20
Transitional (audible and mostly intelligible)	0.20 to 0.40

Design Strategies - Background Noise and Exterior Noise Emissions
Mechanical system should be designed to minimize operational noise impacts to occupied spaces.

For intrusive exterior noise, select exterior wall construction to reduce intrusive exterior sounds to achieve average background noise levels for the type of use for the space, in accordance with the *HVAC-Related Background Sound In Rooms,* as described in the current version of the ASHRAE Applications Handbook (Table 34 in Chapter 47 of the 2003 edition).

Design the mechanical systems to achieve background noise levels for the type of use for the space according to the *HVAC-Related Background Sound In Rooms,* as described in the current version of the ASHRAE Applications Handbook (Table 34 in Chapter 47 of the 2003 edition).

For noise emissions from building systems to the community, all World Trade Center projects must comply with the New York City Noise Control Code.

New York City's Noise Control Code

Ambient noise quality zone	Day-time standards (7am - 10pm)	Night-time standards (10pm - 7am)
Noise quality zone N-1 (Low density residential RL; land-use zones R-1 to R-3	Leq=60 dB(A) measured for any one hour	Leq=50 dB(A) measured for any one hour
Noise quality zone N-2 (High density residential RH; land-use zones R-4 to R-10)	Leq=65 dB(A) measured for any one hour	Leq=55 dB(A) measured for any one hour
Noise quality zone N-3 (All Commercial and manufacturing land-use zones)	Leq=70 dB(A) measured for any one hour	Leq=70 dB(A) measured for any one hour

Means and Methods

1. Room Acoustics
Incorporate sound absorbing finishes to absorb excess sound energy and minimize the build up of noise.

For spaces where the presentation of speech is important, provide sound reflecting surfaces to enhance the propagation of sound from the podium/stage to the audience.

Where possible, provide sound absorbing materials on the ceilings of lobbies and corridors to minimize the build up and transmission of conversations and activity noise.

2. Speech Privacy and Sound & Impact Isolation

Plan the layout of spaces so that spaces with louder activities or programs are not adjacent to spaces that are sensitive to intrusive noise. Incorporate storage spaces, closets, or corridors between louder spaces and noise sensitive spaces.

Orient the building or locate noise sensitive interior spaces so that they have minimal exposure to intrusive exterior noise sources.

For enclosed spaces, select construction approaches that include specially designed acoustically damping partitions, double or staggered studs (without bracing, such as UL Design No. 493), multiple layers of drywall, resilient elements, and stud cavity insulation.

Seal the edges of construction materials, especially where they come in contact with structural elements, such as structural ceilings, floors, and columns, using non hardening sealants. Generally, these sealants consist of silicone, acrylic, or latex and should comply with the VOC requirements of LEED for sealants. This is particularly important where partitions meet the underside of composite metal decks.

Minimize penetrations that may weaken the sound isolating performance of the construction. Where penetrations are necessary, seal effectively with non-hardening caulk or a flexible fire-stopping product. Avoid back-to-back outlets in demising walls; where necessary seal the rear of the outlet box to be airtight.

For open office spaces, use sound absorbing ceilings with high performance (NRC 0.85 or higher), partial height barriers with sound absorbing surfaces, and speech privacy systems that provide a uniform coverage of background noise at 45 to 48 dBA.

For noise sensitive spaces that are exposed to intrusive exterior noise, specify insulating glazing with an interior pane of laminated glass or panes with two different thicknesses. For spaces that desire very low noise levels, or for conditions with excessive exterior noise exposure, incorporate an interior storm panel that captures an airspace of 2 inches or more from the primary insulating glazing unit.

Use carpeting, resilient floor underlayments, or resiliently suspended ceiling constructions to minimize the transfer of impact noise to sensitive spaces below.

3. Background Noise and Exterior Noise Emissions
Plan the placement of mechanical and electrical transformer equipment to be remote from noise sensitive spaces. Include buffer spaces, such as corridors or storage rooms to provide isolation.

Select quiet mechanical systems, such as underfloor plenum air distribution, and slightly oversized ductwork to minimize the generation of mechanical noise.

Use variable speed controllers to reduce the operating capacity of equipment when demand is low, as this will often also reduce noise levels from this equipment. This strategy also contributes to efficient use of energy.

Incorporate noise and vibration control specific for the equipment, such as sound attenuators, mufflers, or vibration isolators.

Design and layout ducted air distribution systems for low pressure air delivery. For noise sensitive spaces, design airflow velocities to be consistent with those listed in table 4 in Chapter 47 of the 2003 ASHRAE Applications Handbook.

4. General

To enhance indoor environmental quality, select noise control insulation materials that encapsulate any fibrous media with protective liner facings. The most effective materials are referred to as "hospital-grade". Minimize the use of internal duct lining by using appropriate and sensible applications of flexible ductwork. Where duct liner must be installed, i.e. in fan discharge and inlet plenums, limited sections of duct risers and mains, and in variable air volume boxes, use protective liner facings, with perforated double wall construction and mylar or equal facings inside the liner, in accordance with the requirements of the NYSGBTC. (External insulation and closed cell foams are not acceptable acoustical substitutes for internal glass fiber lining.)

Project teams are encouraged to consider use of acoustical products that contain recycled content (mineral fiber and glass fiber ceiling tiles, resilient underlayments, cellulose or cotton fiber insulation), are locally produced (sound attenuators, acoustical ceiling tiles, sound absorbing panels), consist of rapidly renewable materials (cork underlayments, cotton fiber batt insulation), or use certified wood (sound transparent wood slat ceilings).

Case Studies

ASID Sound Solutions - Integrating Office Productivity through Integrated Acoustic Planning and Noise Reduction Strategies, 1996

This report studied the productivity benefits of good acoustic planning and design for office workers in an open plan work environment. The research concluded that high performance sound absorbing ceilings, partial height sound absorbing barriers, and a uniform coverage of background noise can increase worker productivity and satisfaction.

Herman Miller MarketPlace, Zeeland, MI

The goal of the client was to create an office prototype to support progressive business practices within a sustainable environment. The intent was that this speculative office building would be an exemplar – an ideal place to work -- while also illustrating the benefits of sustainable design principles to other potential developers. Specific measures were taken to ensure that the building would be both a pleasant and productive workplace. One area of special concern was occupant acoustic comfort. Acoustically absorbent materials were specified to mitigate the reflection of internal sounds and keep noise from becoming disruptive. A fountain in the building's atrium was used to create 'natural' white-noise to help keep other sounds from becoming a distraction to building occupants.

Reference

Definitions

Impact Insulation Class (IIC) is the rating of impact isolation for a floor/ceiling construction. The IIC of floor/ceiling construction is a measure of the sound pressure level in the lower space as the result of a standardized tapping machine operating on the floor above. The values of this rating are measured in accordance with ASTM E492 and determined by ASTM E989. Higher IIC ratings indicate better performance. Most building codes require a minimum IIC rating of 50; IIC ratings of 60+ are recommended for more sensitive spaces, such as luxury residences..

IIC Strength**:** Helps to rate structure-borne noise such as footfall, a chair dragging on the floor, or other realistic sounds in a single number.

Noise is essentially sound that is unwanted, disturbing, or distracting.

Noise Reduction Coefficient (NRC) is the fraction of sound energy that a material absorbs. This value represents the average of the octave band frequencies between 250 Hz and 2,000 Hz. The values for this rating are measured according to ASTM C423. The range of possible NRC values is from 0.00 to 1.00. Most sound reflecting materials, such as drywall, wood, glass, and concrete, have NRC ratings of 0.05 to 0.10. High performance sound absorbing materials have NRC values of 0.70 or higher.

Sound Transmission Class (STC) is the rating of airborne sound transmission. The STC of floor/ceiling (or wall) structure is a weighted measure of the decibel difference between the airborne sound energy striking one side of the structure and the sound energy radiated into a receiving room on the other side. The weighting of this rating system assesses speech and television type sounds most appropriately. Sounds with significant low frequency (music with bass, mechanical noise, and transportation noise) are not as effectively rated using this system. ASTM E90 is the test standard used for measuring this rating. Higher STC ratings indicate high sound isolation. Most codes require STC 50 or greater constructions; very sensitive or very loud spaces may require constructions with STC ratings of 60+.

Speech Privacy Systems are electronic systems that provide a broadband background noise source with uniform coverage and an adjustable level of sound, which is tuned to coincide with, and cover, speech frequencies. The constant presence of this sound renders other random sounds less noticeable. It is also referred to as sound masking or white noise systems.

White-Noise is random noise consisting of equal energy per frequency band. It sounds similar to static on a radio or the airflow noise from a fan.

Standards

ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method (most recent revision in 2002)

ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements (most recent revision in 2004)

ASTM E492 - Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine (most recent revision in 2004)

ASTM E989 Standard Classification for Determination of Impact Insulation Class (IIC) (most recent revision in 1989)

ASTM E1374 - Standard Guide for Open Office Acoustics and Applicable ASTM Standards (most recent revision in 2002)

Bibliography

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Acoustics IEQ-11-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●		●	●	○	○
		Ⓔ	Ⓔ		

☐ **Required Component:**
Mechanical equipment and other sources of noise have been located away from areas of the building and exterior spaces designed for use by building tenants and the public. Separations between these spaces have been designed to minimize the transfer of noise.

☐ **Required Component:**
Strategies to reduce the transmission of exterior ambient noise into the building have been considered and employed.

☐ **Required Component:**
Compliance with the recommendations of ASHRAE Applications Chapter 46 Design Guidelines has been met to reduce vibration from mechanical equipment.

☐ **Required Component:**
Compliance with the recommendations of Architectural Graphic Standards 8th Edition: Sound Isolation Criteria Table, page 44 has been achieved to address acoustic criteria for enclosed office spaces, meeting rooms and other occupied areas.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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Lighting Quality IEQ-12

Purpose: Employ advanced lighting design to maximize comfort and productivity of building occupants and enhance the quality and efficiency of electric lighting. Fully coordinate ambient electrical lighting design with daylighting strategies.

Action: Design an ambient electrical lighting system that is coordinated with daylighting strategies to provide flexible illumination. Endeavor to meet the recommendations of the Illuminating Engineering Society of North America's (IESNA) 9th Edition Handbook, Chapter 10 Quality of the Visual Environment, and the Lighting Design Guide. Provide high frequency electronic ballasts, recyclable lamps and low mercury/low lead lamps as defined by the US Environmental Protection Agency's Toxicity Characteristic Leaching Procedure (TCLP) testing procedure. Supplement ambient lighting system with multi-level task lighting to maintain a minimum of 35 foot-candles (in typical office area) at desk level throughout hours of occupancy.

Related Guidelines: EEQ-1, EEQ-2, EEQ-3, EEQ-6, IEQ-2, IEQ-10

Introduction/Context

Much has been said and written about the importance of high quality, energy efficient lighting in the business environment; nonetheless, the subject remains curiously elusive. Lighting quality is not addressed in any of the LEED Green Building Rating Systems. Indoor lighting in US commercial buildings consumes more than 30% of building energy. Reducing this figure must be a central component of any high-performance building program. One of the keys to a successful sustainable design strategy lies in achieving significant reductions in lighting energy consumption, while also enhancing the quality of lighting in a wide variety of spaces within the building.

In a sustainable approach to design, significant attention is focused on human well-being considerations, which are known to contribute to increased job satisfaction and higher productivity. While there are several factors influencing these goals, including indoor air quality (IAQ) and thermal comfort, lighting quality, in this context, is a major consideration. Providing building occupants with individual and/or group lighting controls allows them to manage light levels for personal comfort. Tailoring lighting strategies to reflect the different requirements of a variety of spaces, will add to flexibility and result in a more responsive lighting strategy.

A well designed lighting strategy includes energy conservation, the integration of electrical lighting and daylighting strategies, maximum visual comfort, the design of flexible lighting plans for specific tasks and designing for computer environments, which requires careful control of glare. According to Judith Heerwagon,"Interior ambient quality can affect work performance. The key factors associated with differential performance are the thermal environment, especially temperature, humidity level, and ventilation, air quality, *and lighting*."

Relevant Issues

Ecological

The circadian rhythm, or twenty four hour biological clock, establishes the daily cycles of most living creatures, including human beings and plants, and is influenced by the rising and setting of the sun. Scientists confirm that animals and plants become disoriented when subjected to constant and unchanging light levels over a period of twenty four hours. Dim lighting levels are perceived as being restful, while brighter levels enhance the ability to focus and become energized. Building lighting that is designed to be flexible, accommodating changing and different needs will increase human comfort and well-being, and has the potential to contribute to increased productivity.

Reducing lighting power densities and loads, without reducing the quality of the light, will reduce the pollution associated with electrical utilities which must generate power to run the lights and the air conditioning to remove heat generated by the lights.

Economic

A sustainable approach to lighting design can save as much as 50% to 60% in energy costs over a typical lighting installation. Using the latest methodologies for efficiency, while considering lighting quality and appropriateness of light levels, this number can still be achieved, even with the recently upgraded and more rigorous ASHRAE Standards. At 50% savings, this translates into a 15% reduction in total building energy costs, not an insignificant saving.

The latest generations of high performance lighting solutions, which integrate several technologies into a single system, are fairly expensive (adding to 'first cost'). However, according to BC Hydro in British Columbia, the installation of an 'intelligent system' capable of delivering superior lighting quality, which is both easy to control and easy to use, can pay back the incremental cost over a typical, good quality baseline system, in less than 1.8 years. The payback in New York City should be quicker, as utility rates are significantly higher in the North East of the U.S.

A task/ambient system is the most appropriate lighting strategy for office buildings. Pendant direct/indirect lighting fixtures, which may be used as part of such a system, as a preferred sustainable approach to achieve high lighting quality, have a cost premium over recessed fixtures. However, the productivity increase that results from a well-lit space with comfortable ambient lighting and minimized glare achievable with these fixtures quickly offsets the incremental first cost impact.

Consideration of avoided health impacts through the minimization of power plant generated air pollution is another economic factor. A reduction in the amount of CO and CO_2 gasses, as well as NOx, SO_2 and mercury vapor, a byproduct of power generation, means that there will be less air pollution overall, and less acid rain components and mercury to affect the water quality up-state and in New England, providing healthier conditions for people and cleaner habitat for wildlife, especially fish. Generation of less particulate matter means there will also be a reduction in ground-level smog near the site, reducing the potential for asthma in sensitive people.

Neighborhood

Interior lighting quality primarily affects those who work within the building, and building occupants are found to be more satisfied with their work and learning environments when provided with a flexible, well balanced and glare-free lighting environment. An attractive, varied lighting scheme that reflects and reinforces day-light during the late afternoon and winter working hours adds a dimension of quality to the interior environment for workers and for visitors alike.

An integrated lighting approach which combines day-lighting with high-quality, responsive supplemental electric lighting reduces energy demand, and therefore reduces pollution from the generation of power for lighting energy. This contributes to cleaner air and benefits the neighborhood. A subtly-lit building that glows in the evening hours without causing light pollution is welcoming, and can be an attractive asset to the area.

Methodology

Design Strategies

There are some broad strategies that can guide the development and implementation of an advanced, energy efficient lighting installation, closely allied with superior lighting quality:

<u>Integrate Electric Lighting Strategies with Daylighting:</u>

Maximum use of daylight – a free resource -- reduces energy needs and provides a connection to the outdoors, which in turn contributes to human well-being and productivity gains. Daylighting here in the North East, can provide much of the lighting requirement in an office building with a relatively narrow footplate, except in the late afternoons and darkest days of winter. However, day-lighting needs to be integrated with supplemental lighting for the greatest gains. In such a strategy, a constant foot candle level can be pre-set and maintained at desktop, either via natural light or by supplemental light, which 'kicks in' to support the fading daylight.

This strategy is achieved through the use of photometric light sensors, or photo-cells, and can be fine tuned via the use of a computer model designed to optimize energy use in the building. Energy conservation can be further enhanced through the use of occupancy sensors.

<u>Deep Daylighting</u>

Deep daylighting strategies increase the penetration and distribution of daylight, which in turn reduces the need for supplemental lighting. Day-lit spaces or continuous access to daylight are considered to be assets and are pleasing to most people, thereby contributing to occupant satisfaction and increased productivity.

Place Light where it is Needed

A task/ambient lighting system with pendant light fixtures is an excellent approach to providing overall (ambient) light, with individual task lighting providing essential, focused light for specific activities.

Visual Comfort

Computers now dominate most office interiors, so integrated lighting schemes must be designed for visual comfort and to minimize glare by keeping potential reflected light from screens. This can be achieved in a number of ways, including the careful coordination of space plan layouts with the lighting plan layouts (integrated design) in the design phases.

Enhanced lighting quality, with flexible controls, multiple levels of light-output or luminance, and reduced glare improves the environmental quality of the work space. The building community enjoys well-lit spaces that achieve a balance between daylighting and artificial light. Levels of luminance are designed to support specific tasks and activities, not to flood all areas with equal levels of bright light. Larger spaces are enlivened by a thoughtful approach to lighting quality that is designed to eliminate a dark and gloomy atmosphere at the back wall, furthest from the windows. Minimizing glare removes the potential for eye-strain, while keying light levels to the softer, lower levels that the human eye is historically accustomed to accommodate, tends to create a more restful ambiance than the typical, over-lit office space.

Means and Methods

Integrated, high quality lighting is most effective when planned early in the design phases. The fenestration of the building, depth of window reveals, type of permanent shading devices and choice of glazing, all have an impact on lighting quality and control strategies. It is preferable to avoid the use of tinted or reflective glazing which reduces the amount of daylight able to enter the interior and conflicts with strategies to enhance the quality of the space and reduce energy consumption by optimizing daylighting.

Integrating Electric Lighting Strategies with Daylighting:

Daylight integrated task/ambient lighting systems with pendant light fixtures often link the first two or three rows of pendant fixtures closest to the window wall to a photo cell, which will dim lighting levels based on measured available daylight and a pre-set foot-candle level at the desktop. These systems contribute to energy conservation by responding to available daylight levels, minimizing the need for electric light on bright days and allowing the supplemental system to increase its out-put on dull days, or at any time when daylighting is insufficient to maintain the pre-set foot-candle level. Photo-sensors synchronize fluorescent lamp light out-put with available daylight, allowing lamps to dim or brighten in accordance with changing weather patterns and time of day or month. Task lights are occupant-controlled and need to have flexible levels of luminance in order to adequately accommodate different tasks and variations in occupant needs – for instance, given a choice, an older person will generally choose a brighter level of task lighting than a young person.

To optimize daylight dimming or photo-cell efficiency, lay out fixtures in rows that run parallel to window walls. Where rooms are large or run to a depth of 15'-0" or more, and which are designed to take advantage of as much daylighting as possible, balance the lighting levels by providing vertical illumination at walls furthest from windows or skylights. This strategy can be achieved via wall washers or pendant fixtures placed within two to three feet of the back wall.

A number of energy efficient, integrated lighting systems have been introduced in recent years to the marketplace. These are the new 'intelligent' systems that integrate an entire suite of technologies into a single system that is easy to manage, while providing great flexibility and control. One such system integrates network controls, occupancy sensors, daylight photo-cells, and personal dimming systems, and provides monthly reports detailing energy usage on a system-wide basis. These systems have been demonstrated to reduce lighting power density to 0.5 watts per square foot, and to achieve conservation of more than 80% over typical baseline models.

Deep Daylighting

Deep daylighting is enhanced by ceilings designed to slop upward from the window wall towards the building core or center, and by louvers or light shelves set inside window frames, which bounce the light onto the ceiling and deep into the space. Shading devices can be used to control low western sun in the afternoon, and help to manage thermal comfort, especially in buildings which do not have the advantage of smart glazing technologies.

Locations of interior office or room partitions and high workstation panels must also be considered. To the extent possible, both full height permanent and moveable partitions, including workstation partitions, should be run perpendicular to the window wall. This will allow for maximum interface and efficiency to occur between daylighting and electrical lighting controls. Use of glazed or translucent interior walls, high level clere-stories and low partitions all assist in maximizing the lighting quality of the interior space. Bright, light colors on walls help to optimize lighting quality, and white ceilings with high reflectance characteristics assist daylight penetration, contributing to the cheerfulness of the space in almost all cases. Medium to light architectural finishes, such as carpeting, and bright, light colored furniture and furnishings, such as workstation partitions and desktops, will further enhance this deep-daylighting strategy.

Place Light where it is Needed

Pendant ambient lighting systems require ceiling heights of 8'-6" minimum, and higher if possible. They eliminate the 'glaring headlights' syndrome, where flush, recessed fixtures appear uncomfortably bright against a shadowed background, even with a white ceiling. Ideally, for good light distribution, pendant fixtures with an up-lighting component should hang no less that 1'-6" from the ceiling. The up-light component will provide a sense of a bright, overhead canopy, allowing the down-light component(s) to provide low-level ambient lighting, sufficient to move comfortably around the space and undertake non-critical visual tasks. Ambient illumination levels should be lower than task lighting levels by approximately one third, in order to accommodate the human eye and prevent eyestrain.

Visual Comfort

Consider the Visual Comfort Probability (VCP) in the design approach. To minimize glare, ambient lighting should have a VCP of 80% for computer heavy spaces and 70% for other areas. The VCP addresses recessed ceiling fixtures and the direct portion of pendant fixtures only, and is defined as 'the percentage of people who find the lighting free from discomfort glare.' This is a little difficult to calculate in the abstract – on large projects, the design team might consider building a full-scale lighting mock-up to ensure that the proposed lighting plan achieves the desired high VCP score.

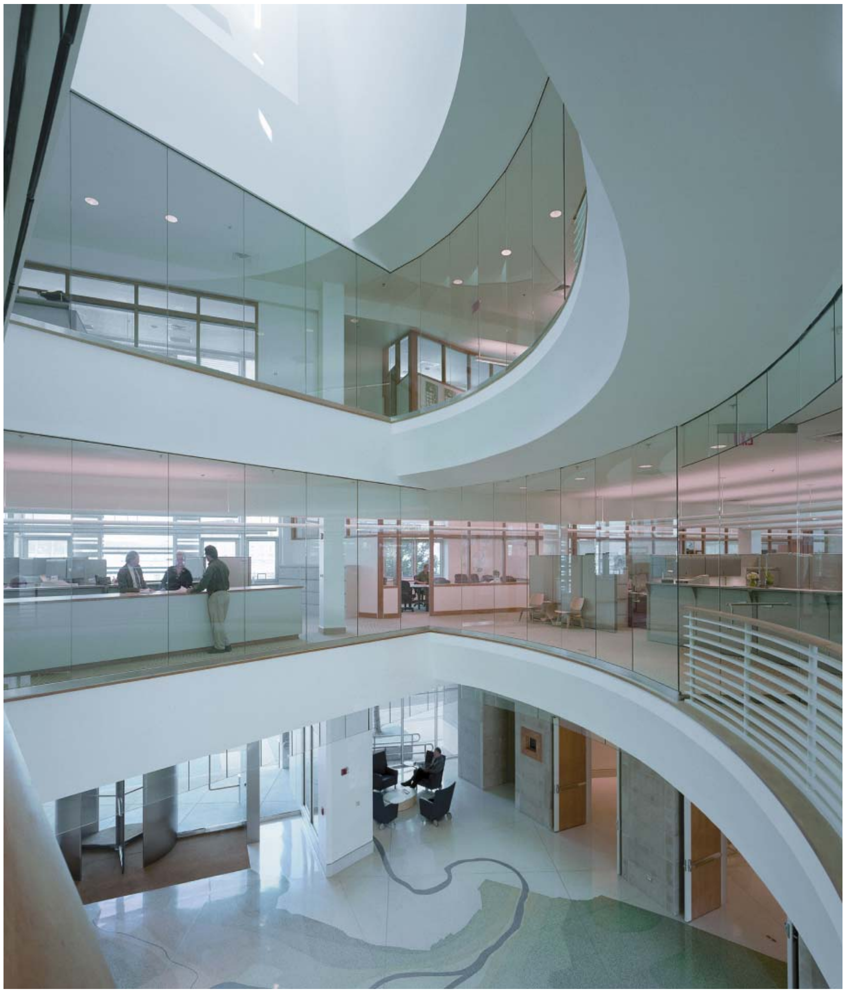
Glare on computer screens can be controlled by an all-up-light (indirect) pendant installation. This creates a rather bright ambient atmosphere, and can cause bright ceiling and fixture reflections to appear in the screens, so computer locations must be flexible to optimize the system. This becomes increasingly easier with the new, compact, flat computer screens, which do not have to be installed in corner locations. Both indirect and direct/indirect pendant fixture, ambient lighting schemes are preferred over recessed or flush-mounted fixtures or downlights. Ceiling luminance designed to enhance conditions for computer tasks in both of these options is recommended to have a ratio across the ceiling of 4 to 1. The luminance levels at ceiling and wall surfaces should not exceed 850 candelas per square meter at any angle, averaged over a 2 by 2 square foot area.

In computer heavy facilities, ambient light levels should be maintained at less than 30 foot-candles, which is comfortable for the work area. Low ambient light levels need to be supplemented by flexible task lighting at each occupant desk or work station, with variable light level settings, up to a maximum high of 50 foot-candles. (See the IES RP-1 Guidelines).

Case Studies

The Chattanooga Development Resource Center, Chattanooga, Tennessee
This building consolidates the majority of city/county governmental agencies and divisions related to the built environment for the City of Chattanooga and Hamilton County. The building embodies many important principles of sustainability and environmental quality in a highly productive 'transparent' and flexible workplace for the officials and planners charged with bringing Chattanooga into the 21st century. High quality lighting is achieved throughout the building via the integration of day-lighting and supplemental electric lighting. Sloped ceilings and perimeter louvers bounce light from exterior openings into occupied spaces, while photo-sensors optimize energy conservation through the continuous coordinated dimming of electric light. Customized day-lighting from high impact/direct beam traversing light in circulation areas to low impact/diffuse light in office areas.

In post-occupancy interviews employees have expressed personal satisfaction with the quality of lighting and the integrated electric lighting and day-lighting strategies in the building, which they feel, contribute to an enhanced daily work experience.



Chattanooga Development Resource Center – Main Lobby with Skylight: Photograph by Timothy Hursley

Chattanooga Development Resource Center – West Sunset Effect. Photograph by Timothy Hursley

Reference

Definitions

Circadian Rhythm Biological cycle lasting approximately 24 hours: In human beings, the circadian rhythm is controlled by a biological clock, called the suprachiasmic nucleus, found in the hypothalamus Its perturbation can bring about illnesses and sleep disorders. The circadian rhythms are astonishing in that, although they last about 25 hours, they are capable of constantly synchronizing to the 24-hour day-night alternation.

Standards

Standards have not been included for this Guideline.

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New Buildings Institute. Advanced Lighting Guidelines. White Salmon, WA, 2003

Lighting Quality — IEQ-12-T

Sustainable Design Guidelines Reference Manual
WTC Redevelopment Projects

Project Name: ______________________________

Phase:

SD	DD	CD	FINAL
☐	☐	☐	☐

Legend:

- ● Action Required
- ◉ LEED™ Equivalency Option allowed
- ○ Action Recommended
- Ⓔ Exemplar model

Project Type:

Transportation Hub	Site/Parcel	Commercial Office	Commercial Retail	Memorial	Cultural
☐	☐	☐	☐	☐	☐
●	●	●		○	○
		Ⓔ	Ⓔ		

☐ **Required Component:**
The ambient electrical lighting system for the project has been designed to coordinate with daylighting strategies.

☐ **Required Component:**
Effort has been made toward meeting the recommendations of the Illuminating Engineering Society of North America's (IESNA) 9th Edition Handbook, Chapter 10 Quality of the Visual Environment, and the Lighting Design Guide. A brief description of strategies employed to provide a high quality lighting environment is attached.

☐ **Required Component:**
High frequency electronic ballasts and recyclable lamps have been provided. Lamps are low mercury/low lead as determined by the US Environmental Protection Agency's Toxicity Characteristic Leaching Procedure (TCLP) testing process.

☐ **Required Component:**
The ambient lighting system has been supplemented with multi-level task lighting to maintain a minimum of 35 footcandles (in typical office area) at desk level throughout hours of occupancy.

Name ______________________ Signature ______________________

Company ______________________ Role in Project ______________________

Date ______________________

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