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Commissioning to avoid indoor air quality problems

The commissioning process will help avoid IAQ problems and improve occupant comfort in new and renovated buildings

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Indoor air quality (IAQ) has become a pervasive problem plaguing the building industry worldwide. Poor IAQ in commercial and office buildings is primarily related to new building technology, new materials and equipment and energy management operating systems.

Occupants of buildings with air quality problems suffer from a common series of symptoms. These symptoms include eye, nose and throat irritation, dry skin and mucous membranes, fatigue, headache, wheezing, nausea and dizziness.[1] Although these symptoms are of significant concern and may in a limited number of cases lead to building related illnesses, by far the biggest problem facing the engineering community is discomfort, rather than serious health impairment.

Discomfort leads to increased absenteeism, reduced performance and productivity and often is the reason why tenants choose to relocate.[2,3] Discomfort can also result in significant lawsuits.[4] The costs associated with poor IAQ may be substantial and far outweigh the savings from reduced energy consumption.

As early as 1982, ASHRAE, realizing the significance of the problem, produced an IAQ position statement that identified strategies for solving IAQ problems.[5,6] Many of those strategies have now been implemented, including *Standard 62-1989, Ventilation for Acceptable Air Quality*;[7] *Standard 90.1, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*;[8] the 100 series of energy standards; and *Guideline I, Guideline for Commissioning of HVAC Systems.*[9]

In the opinion of many experts and practitioners in North America, the central feature of this comprehensive IAQ strategy is HVAC commissioning. The original ASHRAE *Guideline for HVAC Commissioning* did not focus on IAQ control. However, a committee is now revising the guideline and will include recommendations for avoiding IAQ problems in new buildings.

Extent of the IAQ problem

Numerous surveys have quantified the magnitude of IAQ problems in existing buildings. Possibly the most extensive survey is the 1991 Steelcase Worldwide Office Environment Index.[10] This survey reports opinions of office workers, top executives, facilities managers and contract design professionals in 15 countries including the United States, Canada, Japan and member countries of the European Economic Community. This survey provides a benchmark of worldwide opinions regarding HVAC performance and IAQ.

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Without exception, poor air quality is perceived as a serious hazard by office workers throughout the world: 37% of the respondents in the United States; 46% in Canada; 39% in the EEC; and 53% in Japan. Comfortable heating and air conditioning are perceived to be very important by a substantial majority of office workers: 82% in the United States; 84% in Canada; 85% in Japan; and 72% in the EEC.

On the other hand, a majority of office workers feel that comfortable conditions are not being provided: 56% in the United States; 63% in Canada; 55% in Japan; and 63% in the EEC. Worldwide, there is a large gap between building occupants' expectations for comfort and IAQ and what they feel is being provided by the buildings in which they work.

According to the Steelcase survey, both building managers and designers appear to agree with the occupants. In the United States, 39% of managers and 61% of designers feel that comfortable heating and air conditioning are not being provided. Possibly of more importance for new building design and renovations, 87% of managers and 85% of designers feel that comfort must be provided by the HVAC systems.

Causes of IAQ problems

Government organizations and private sector consultants in North America have undertaken extensive investigations to diagnose and mitigate IAQ problems. *Table 1* presents a summary of specific causes of the sick building syndrome provided by the U.S. National Institute of Occupational Safety and Health[11] and Health and Welfare Canada.[12]

The findings of both government agencies are remarkably similar. In 52% of their investigations, inadequate ventilation (e.g., low ventilation effectiveness, inadequate fresh air intake and poor temperature control) was identified to be a causal factor.

Also, 12% to 16% of IAQ problems were related to indoor generated contaminants (including photocopy machines and tobacco smoke) and 9% to 10% were related to the infiltration of outdoor contaminants (e.g., motor vehicle exhaust entering the building). Other identified factors include contamination from building fabric and materials (2% to 4%) and microbial problems (0.4% to 5%). The cause of IAQ problems could not be determined in 12% to 24% of the investigations.

The experiences of private sector researchers have shown similar results. Collett,[13] Robertson[14] and Rask[15] have all found HVAC-related inadequacies to be the primary cause of IAQ problems.

Table 1. Causes of Indoor Air Quality Problems[1]

Problem Type	NIOSH Survey[2] Number	%	HWC Survey[3] Number	%
Inadequate ventilation	252	52	710	52
Indoor contaminants	77	16	165	12
Outdoor contaminants	48	10	125	9
Building fabric	20	4	27	2
Biological contamination	26	5	6	0.4
No problem found	61	12	329	24

1. Surveys conducted by U.S. National Institute of Occupational Safety and Health (NIOSH) and Health and Welfare Canada (HWC) in 1,846 white-collar workplaces.
2. NIOSH survey conducted in 484 buildings; see Crandall, 1987.
3. HWC survey conducted in 1,362 buildings; see Kirkbride, 1990.

Commissioning as the solution

The North American experience clearly demonstrates that a properly designed, well constructed, properly functioning and well maintained HVAC system will reduce, if not eliminate, the majority of IAQ and comfort complaints by building occupants. The process by which this can be achieved is HVAC commissioning.

Commissioning of a HVAC system is not simply starting it up after construction and making sure that the equipment is in working order. Instead, commissioning is a process of system delivery that begins when a project is conceived and ends when the useful life of the resulting structure is complete. ASHRAE *Guideline 1* defines commissioning as "the process of achieving, verifying, and documenting a concept through design, construction, and a minimum of one year of operation."[9]

The ASHRAE guideline establishes procedures for the HVAC commissioning process for five phases of a project: program, design, construction, acceptance and post-acceptance. The phases are shown in *Figure 1*. A fully functioning, fine-tuned HVAC system with complete documentation is the end-result of the successfully applied commissioning process.

Of course, commissioning is much more than consideration of IAQ concerns. However, IAQ considerations should be addressed at each phase of the process to avoid sick building syndrome problems.

The following checklist has been developed as a guide to be used by the commissioning authority during the commissioning process to verify that IAQ requirements have been adequately addressed by members of the design and construction teams. The commissioning authority will be the designated person, company or agent that will plan and carry out the overall commissioning process.

The design professional, contractor, owner's representative or independent third-party may be the commissioning authority, and they may assign a specialist to this IAQ checklist. The purpose of this checklist is to ensure that IAQ considerations are raised in a coordinated manner at the appropriate time during the design and construction process. Further, the checklist provides guidance for the building owner and/or operator regarding on-going operational and management procedures that are necessary to maintain optional IAQ and comfort conditions.

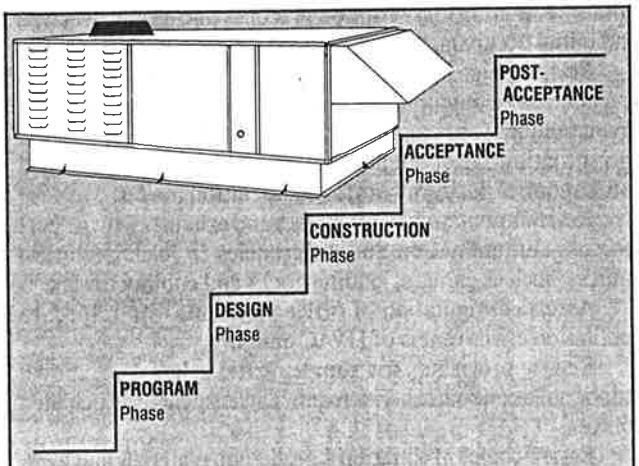

Figure 1. The five phases of the HVAC commissioning process.

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Program phase. Review projected occupant activity, density and locations on which the HVAC design was based. Attention should be paid to special use areas such as kitchens/break areas, smoking lounges, meeting/conference rooms and printing/photocopying areas. Appropriate standards should be referenced.

Identify major outdoor sources of pollutants in the vicinity of a building site (such as exhaust systems, cooling towers of neighboring buildings and existing or proposed parking garages). Prevailing wind direction should also be taken into account. This may also include an assessment of soil and groundwater that will interact with the building structure.

Identify any need for supplemental exhaust from known sources of indoor air pollution, possibly using transfer air.

Design phase. Examine manufacturers' safety information for products specified in contract documents that may be suspected contributors to indoor pollutants (including carpets, flooring, linen, adhesives, wallcoverings, partitions and ceilings; insulating and fireproofing materials; sealants on windows, walls and floors; and use of paints, varnishes, etc.).

Request manufacturers to provide information on curing, drying and airing procedures for their products to minimize subsequent emission rates. Manufacturers can be asked the following questions:

- What information does the supplier have about emissions of volatile organic compounds (VOCs) from its product after manufacture? What chemical content labeling is included with the product?
- What steps, both in manufacture and post-construction treatment, does the manufacturer take to reduce emissions from its product prior to installation in the building?
- Is it possible for the manufacturer to air-out the product before installation? If so, for how long and under what conditions?

Review installation instructions for proposed adhesive materials (used for installing sealing compounds, wall and carpet adhesives, paints, varnishes, etc.) to ensure minimum use consistent with proper application.

Review design documentation for compliance with applicable air quality, ventilation and thermal comfort codes and standards.

Review design documentation for specification of temporary ventilation and filtration practices during construction and initial occupancy.

Review design intent under all projected modes of operation and anticipated outdoor conditions, such as minimum and maximum outdoor temperatures. Specific attention should be given to ventilation rates, temperature and humidity control and smoke control during all projected operation modes.

Review orientation of air intakes and exhausts with respect to cross-contamination and adjacencies to local pollution sources, such as garages, loading docks and cooling towers.

Assess configuration of office partitions with respect to ventilation effectiveness of HVAC design.

Review provisions for supplemental exhaust of known indoor pollution sources. This requires assessment of anticipated sources.

Review choice of filtration type, design, materials and location within the ventilation system. This should incorporate placement of air filtration systems based on outdoor air conditions and desired indoor contaminant concentrations.

Review specification of HVAC materials according to susceptibility to wind erosion, corrosion and microbial contamination.

Review design of internal air supply system components, such as condensate trays, water baffles, mist eliminators and cooling towers, to control the presence of standing water, thereby minimizing the potential for microbial contamination.

Review design of access doors and/or inspection ports to all chambers and components of air handling system plenums. Access doors on air handling units should be adequately sized and located to allow proper cleaning of condensate pans and/or humidifier reservoirs.

Review specification and placement of HVAC insulation materials with respect to potential microbial contamination.

Construction phase. Review installation of system components (such as condensate pans and humidification equipment to control standing water within the air handling system).

Verify that all critical components of the air supply systems are accessible for future cleaning and servicing.

Verify proper and careful installation of all HVAC insulation materials.

Review implementation procedures for temporary ventilation and filtration practices during periods of construction, such as interior finishing. This may require increased ventilation rates and schedules and the use of items such as temporary operation pre-filters, unitary conditioning/filtering units and removable windows.

When the building is partially occupied during construction, the HVAC system should be operated to isolate the occupied areas from areas where construction is occurring. For example, this could be achieved by maintaining a relative positive pressure in occupied zones and diverting return air from the construction zones directly outdoors.

Acceptance phase. Examine all HVAC internals and filters for cleanliness and readiness for operation.

Test and verify effective operation of all air handling system components that use free water, including humidification control equipment. Proper drainage of water around the building (especially in the vicinity of all outside air intakes) should be verified.

Verify that installed materials and equipment are as specified and that appropriate information has been submitted for all substitutes.

Examine all insulating materials for integrity and proper installation.

Review test and balance reports and compare to design intent. A spot check of ventilation rates and temperature and humidity control is recommended.

Conduct air quality testing (as specified by applicable codes and standards) to verify that IAQ procedures have been effective.

Verify that all system operations and maintenance manuals are available.

All IAQ procedures should be verified, documented and certified.

Post-acceptance phase. Verify adoption of temporary ventilation schedules and rates during and immediately after the acceptance phase.

Review plans for post-commissioning IAQ testing for comparison with applicable standards and codes.

Undertake an ongoing IAQ audit process periodically. The audit should include information on building occupancy and use changes.

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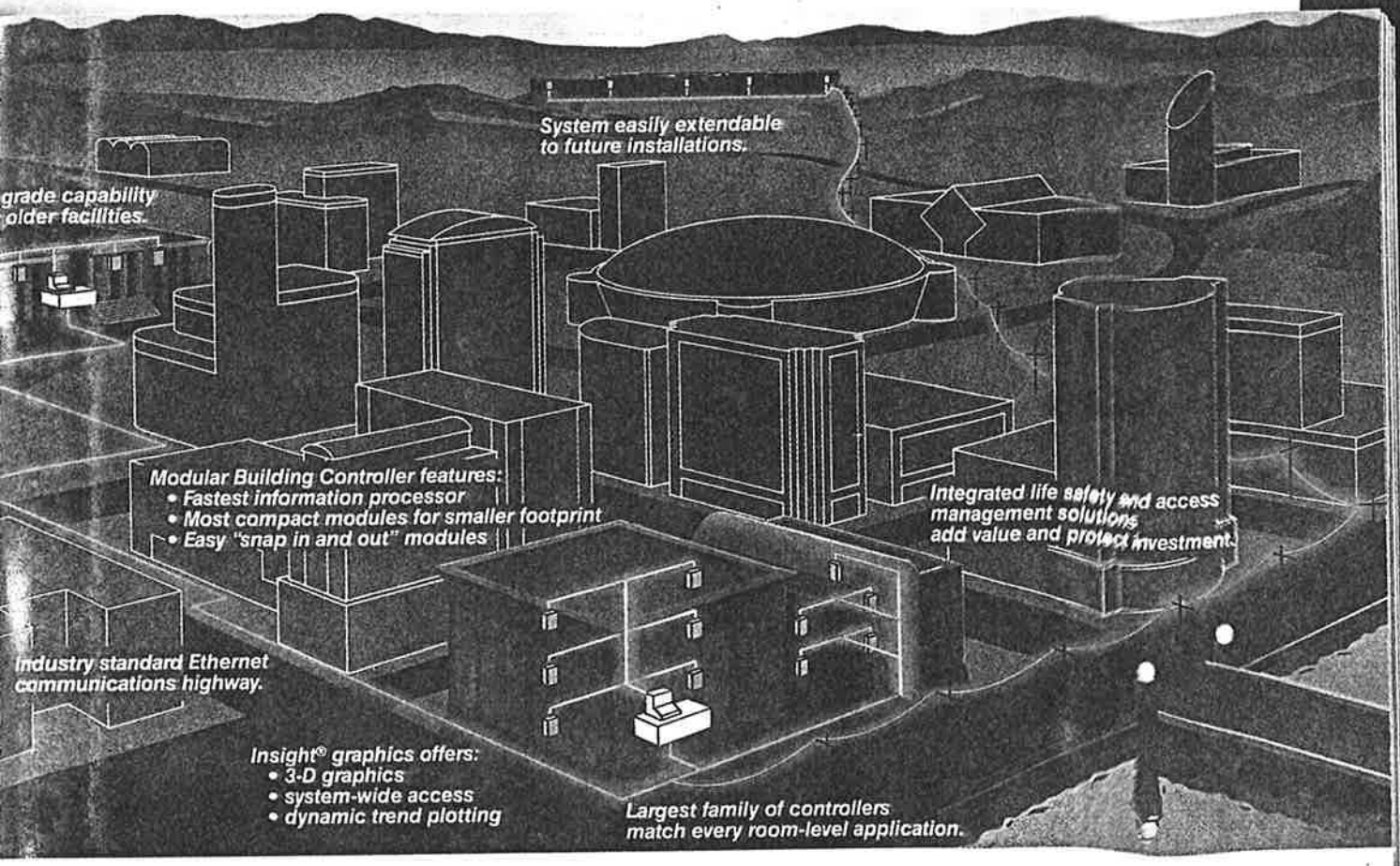

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Discussion

If followed carefully throughout all phases of building design, construction and operation, the process of building commissioning will help avoid IAQ problems and improve occupant comfort.

Based on conservative estimates, commissioning could eliminate as much as one-half of all IAQ-related complaints. In addition, ongoing performance auditing of the building after occupancy could virtually eliminate IAQ and comfort complaints in new and renovated buildings to which the commissioning process has been applied.

Building tenants are clearly sensitive to IAQ and comfort considerations when leasing space in new commercial buildings. Fully leased buildings with satisfied tenants will more than pay for the commissioning process.

Owners should consider commissioning as an indispensable budget item when costing new projects. To recover these costs, marketing agents should include information about commissioning as part of the leasing promotion package.

Acknowledgment

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