COMMISSIONING TO AVOID INDOOR AIR QUALITY PROBLEMS

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ABSTRACT

The risk of indoor air quality (IAQ) problems appearing in new and reconditioned buildings is a concern of significant proportions. In North America, research undertaken by federal agencies has identified the source of IAQ problems to be malfunctioning, poorly maintained, or inadequately designed Heating Ventilation and Air Conditioning systems. These conclusions are based on the investigation of more than 2,000 buildings with IAQ problems. In more than 50% of the buildings, ventilation-related problems were identified.

In 1989, ASHRAE published the first formal guideline for commissioning of HVAC systems. To a great extent, the intent of the guideline was to provide a means of avoiding IAQ problems in newly constructed buildings. However, no IAQ-specific instructions were provided. The guideline is now being revised and will incorporate a section devoted to avoiding IAQ problems in both new and reconditioned buildings.

INTRODUCTION

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, including eye, nose, and throat irritation; dry skin and mucous membranes; fatigue; headache; wheezing; nausea; and dizziness (WHO 1982). 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 and reduced performance and productivity and often is the reason why tenants choose to relocate (Sterling and Sterling 1983; Woods et al 1987). Discomfort can also result in significant lawsuits (LePatner 1987). The costs associated with poor IAQ may be substantial and far outweigh savings due to reduced energy consumption.

As early as 1982, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), realizing the significance of the problem, produced an IAQ position statement that identified strategies for the solution of IAQ problems (ASHRAE 1982, 1987). Much of those strategies has now been implemented, including ASHRAE Standard 62-1989, Ventilation for Acceptable Air Quality (ASHRAE 1989a); Standard 90.1, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings (ASHRAE 1989b); the 100 series of energy standards; and Guideline 1, Guideline for Commissioning of HVAC Systems (ASHRAE 1989c).

In the opinion of many experts and practitioners in North America, the central feature of this comprehensive IAQ strategy is HVAC commissioning (Sterling 1989; Lawson 1989; Stone 1989). The original ASHRAE Guideline for Commissioning did not focus on IAQ control. However, a committee is now revising the guideline and will include the recommendations on how to avoid IAQ problems in new buildings.

EXTENT OF THE IAQ PROBLEM

A number of surveys have quantified the magnitude of IAQ problems in existing buildings. Possibly the most extensive survey is the Worldwide Office Environment Index 1991 (Steelcase 1991). The study reports the 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 (EEC). This survey provides a benchmark of worldwide opinions regarding HVAC performance and IAQ. Without exception, poor air quality is perceived as a serious hazard by office workers throughout the world—37% of the respondents in the U.S., 46% in Canada, 39% in the EEC, and 53% in Japan. Comfortable heating and air conditioning is perceived to be very important by a substantial majority of office workers—82% in the U.S., 84% in Canada, 85% in Japan, and 72% in the EEC. On

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the other hand, a majority of office workers feel that comfortable conditions are not being provided—56% in the U.S., 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 surveys, both building managers and designers appear to agree with the occupants. In the U.S., 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 INDOOR AIR QUALITY 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 sick building syndrome provided by the U.S. National Institute of Occupational Safety and Health (Crandell 1987) and Health and Welfare Canada (Kirkbride et al. 1990).

The findings by both government agencies are remarkably similar. In 52% of their investigations, inadequate ventilation (e.g., poor air circulation, inadequate fresh air intake, and poor temperature control) was identified to be a causal factor. Twelve to sixteen percent of IAQ problems were related to indoor-generated contaminants, including photocopy machines and tobacco smoke. Nine to ten percent 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 et al. (1989), Robertson (1988), and Rask et al. (1990) have all found HVAC-related inadequacies to be the primary cause of IAQ problems.

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 complaints by building occupants. The process by which this can be achieved is building commissioning. Commissioning a building is not simply starting it up after construction and making sure that the equipment is in working order. Commissioning is a process of building delivery that begins when a project is conceived and ends when the useful life of the resulting structure is complete. The ASHRAE Guideline defines commissioning as "the process of achieving, verifying, and documenting a concept through design, construction, and a minimum of one year of operation" (ASHRAE 1989c).

Table 1
Investigations of Problem Buildings by North American Government Agencies

	NIOSH (484 Buildings) Crandell, 1987		HWC (1362 Buildings) Kirkbride, 1990	
Problem Type	Number	Percent	Number	Percent
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

The ASHRAE Guideline establishes procedures for the HVAC commissioning process for each phase of the project:

- program phase,
- design phase,
- construction phase,
- acceptance phase, and
- post-acceptance phase.

A fully functioning, fine-tuned HVAC system with complete documentation is the end result of the 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 during the commissioning process so that IAQ requirements are met.

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, and meeting/conference rooms. Appropriate standards should be referenced.
- Identify major outdoor sources of pollutants in the vicinity of the building site such as exhaust systems, cooling towers of neighboring buildings, and existing or proposed parking garages. Prevailing winds should also be taken into account. This may also include an assessment of soil and groundwater that will interact with the building structure.
- Identify the 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, wall coverings, partitions, and ceilings; insulating and fireproofing materials; sealants on windows, walls, and floors; use of paints, varnishes, etc.
- Request manufacturers 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 after manufacture from its product? 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., ensuring minimum use consistent with proper application.
- Review design documentation for compliance with applicable air quality and thermal comfort codes.
- 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 and extreme outdoor conditions. Specific attention should be given to ventilation rates and temperature and humidity 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 of supplemental exhaust from known indoor pollution sources.
- Review choice of filtration type and 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 free water and minimize microbial contamination.
- Ensure availability of access doors and/or inspection ports to all chambers and components of air-handling system's plenums. Ensure access doors on air-handling units are adequate 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 systems components, such as condensate pans and humidification equipment, to control standing water within the air-handling system.
- Ensure access to all critical components of the air supply systems that will require future cleaning and servicing.
- Ensure proper and careful installation of all HVAC insulation materials.
- Ensure implementation of 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 occupied areas of the building 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 those components of the air-handling systems using 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.

- Verify that all system operations and maintenance manuals are available.

Post-Acceptance Phase

- Ensure adoption of temporary ventilation schedules and rates during and immediately after the acceptance phase.
- Review plans for post-commissioning indoor air quality testing compared to applicable standards and codes.
- Periodically undertake an ongoing IAQ audit process. The audit should include information on building occupancy and use changes.

DISCUSSION

The process of building commissioning—if followed carefully throughout all phases of building design, construction, and operation—will help avoid IAQ problems. Based on conservative estimates, the process of commissioning could eliminate as much as half of all IAQ-related complaints. In addition, ongoing performance auditing of the building after occupancy could virtually eliminate IAQ 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 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.

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