The IAQ TOP 10

From dealing with soiled diffusers to offering a memorable rule of thumb about building pressure, this IAQ consultant and veteran expert witness testifies with this list of critical topics. Designers, operators, and owners can all pick up some tips here to boost occupant satisfaction and ensure that you're not courting trouble with your ventilation.

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The following are my top 10 topics for reducing and fixing IAQ complaints. These 10 items were derived from my 30 years experience in over 2,000 IAQ investigations as well as the opinions collected during a meeting I had with other expert IAQ investigators (Mendel, M. J. et al. 2006).

HEALTHY BUILDING CHECKLIST

- Air temperature (70°F to 74°)
- Air pressure (3 to 7 pascals positive with respect to outdoor air and special use areas)
- Outdoor air ventilation (on prior to and continuous during occupancy, and at least the minimum flow rates as specified by ASHRAE 62.1, or preferably, 15 cfm/occupant and 1.0 ach, whichever is greater)
- Outdoor air inlet (locate away from sources of air contaminants or odors)
- Indoor sources (use low-emitting materials, isolate tenant improvement/construction areas, flush out areas)
- Moisture (don't let materials get and stay wet for more than two days)
- Soiling around supply air diffusers (clean soiling around diffusers and improve air filtration)
- Particle emissions from ventilation systems (fix sound liner erosion and clean ducts)
- Air filtration (minimum of MERV 8 and preferably MERV 11 or 13, no ozone, electrostatics, or UV)
- Occupant complaint/response system (implement one)

AIR TEMPERATURE

In air conditioned buildings, air temperatures should be kept between 70° and 74°. When air temperatures are too warm, occupants often complain that "there is no air," and "the air is stuffy," and generally perceive the quality of the indoor air as being poor.

Apparently, a strong aversion to warm humid air is deeply wired in our brains. This air is often judged as "not being fresh" or "stale." One of my mentors, the late Professor Ole Fanger from the Techni-

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cal University of Denmark, once told me the ventilation "should be served like champagne, cool and dry."

Cooler air is just perceived by the brain as being fresher, and maintaining air temperatures at the cooler end of the acceptable thermal comfort range results in improvements of perceived IAQ. Thermal comfort complaints also comprise the largest source of trouble calls in office buildings. Providing occupants some individual control of the indoor air temperature also improves their perceived acceptability of the indoor air.

2 AIR PRESSURE

More important than outdoor air ventilation, which currently is the only IAQ aspect of the ventilation system performance that is regulated in building codes, is controlling the building space pressures.

Generally, except in very cold climates, you want to have the building air pressures positive with respect to outdoors. Rather than "Sick Building Syndrome," the term SBS more aptly means "Sick Buildings Suck." When a building is operated with a negative air pressure, the result is that many unintended flow rates of air into the building develop, including infiltration of soil gas into the building and infiltration of unfiltered and unconditioned air into the building.

In air conditioned buildings in hot humid climates, the infiltration of hot humid air into wall cavities can result in condensation and mold growth. Also, negative air pressures can make buildings vulnerable to some types of problems. For instance, when a drain trap becomes dry, sewer gases infiltrate into the building if the building has a negative pressure, but do not if there is a positive pressure. So remember that "Sick Buildings Suck" and "Healthy Buildings Blow."

It is also important to keep special use areas that have odors/air contaminants (e.g. bathrooms, janitor closets, garbage rooms, high volume printing/copying rooms) under a negative air pressure with respect to adjacent areas with air being exhausted directly outdoors.

3 OUTDOOR AIR VENTILATION

The supply of outdoor air to a building is essential to the creation of an acceptable indoor air environment. Ventilation is the only way to remove many indoor generated air contaminants from furnishings, equipment, occupants, and their activities.

First of all, the system needs to be designed to bring in outdoor air. Oftentimes, a space that was designed with air conditioning but no outdoor air intake, such as a system for a server room, is converted to an occupied space (e.g. a conference room, office space, or classroom) without modifying the system to bring in the required outdoor air.

Secondly, the control system needs to operate the system when the space is occupied. In many light commercial buildings, thermostats control the small rooftop ventilation systems. These thermostats, like residential thermostats, are equipped with fan switches. The fan switch has both "on" and "auto" operational positions. If the system is allowed to operate with the fan switch in the "auto" position, the fan cycles on and off to control the thermal loads, and does not provide outdoor air ventilation to the space continuously. When the fan switch is in the "on" position, the ventilation system provides outdoor air to the space continuously.

Most building codes require that for spaces without operable windows, a mechanical ventilation system must be installed that has the capability to provide the required outdoor air ventilation. These building codes do not require that the system be actually operated, just capable of operating. In California, the State Labor Code Section 5142 requires that the ventilation system be operated continuously during the hours the building is occupied.

In addition, I recommend that buildings be provided with between one and three air changes of outdoor air prior to building occupancy to remove contaminants and odors that have built up during the night when the building ventilation system is turned off. The exact amount of outdoor air required to purge the building to an acceptable concentration of contaminants will depend upon the specific sources in the building and can be determined on a trial basis using building odor as a criteria.

In hot humid climates, it is important to provide adequate dehumidification of the humid outside air being brought into the building, or moisture problems and mold growth can occur. One way to ensure that proper dehumidification of the outdoor air in hot/humid climates occurs is to have a separate 100% outdoor air ventilation system to provide dehumidified dry outdoor air to the space with separate recirculating ventilation systems to control that actual space temperatures. The minimum outdoor air ventilation rates that should be delivered are those in ASHRAE 62.2, although providing higher outdoor air ventilation rates, will provide indoor air with a higher perceived air quality. I recommend a minimum of 15 cfm/occupant or 1.0 ach, whichever is greater. Remember to "build it tight, but ventilate it right."

4 OUTDOOR AIR INLET

If the ventilation system represents the lungs of the building, the outdoor air inlet represents the nose of the building. It is important that the outdoor air intake is located away from stinky things such as sewer vents, kitchen, and bathroom exhausts, loading docks, garbage dumpsters, etc. It is often difficult to relocate an outdoor air inlet after the building is built so this becomes an important design decision. Apparently, many architects have difficulty with the visual aesthetics of the outdoor air intake and put it in the rear of the building with the loading dock and garbage dumpsters. Having the outdoor air intake located on the roof of the building also is more secure than one at ground level.

5 INDOOR SOURCE CONTROL

Make sure to use low-emitting materials and finishes, and cleaning products. Avoid using products with urea-formaldehyde resins such as composite wood products like medium-density fiberboard and particleboard. These products can emit significant amounts of formaldehyde gas into the indoor air for many years after installation.

Formaldehyde is both a known human carcinogen and a potent eye and respiratory system irritant. There are composite wood products available that use alternative resins that do not emit formaldehyde. The Collaborative for High Performance Schools (CHPS) has a list of products on its webpage (*www.chps.net/manual/lem_table.htm*) that meet the strict material contaminant emissions criteria of California's Architectural Specification 01350. Use these products wherever possible and following painting and carpet installation, configure the ventilation system to provide 24/7 ventilation with the maximum percentage of outdoor air that is possible to flush away fumes.

Typically, flushing the building continuously for a few days to two weeks results in a satisfactory reduction of indoor emissions. The exact duration will depend upon the specific sources in the building and can be determined on a trial basis using building odor as a criteria. When construction and tenant improvements are being performed in an occupied building, it is very important to isolate the work area from the occupied area, including shared ventilation systems. The days of simply posting a sign "Pardon the Dust" are long gone.

6 MOISTURE CONTROL

Controlling moisture in a building so that it does not accumulate is essential to preventing mold from growing, disseminating mold spores into the indoor air, and degrading the IAQ. As described in the "*A California Builders' Guide to Reducing Mold Risk*" (*http://iee-sf.com/workshops-seminars/pdf/BuildersMoldGuide.pdf*) the three strategies for reducing mold risk are:

1) Keep the water away with proper site drainage.
2) Keep the water out with proper window/door flashing, foundation waterproofing, vapor retarder placement, and wall drainage system.
3) Limit mold growth while moisture dries out with selection of moisture-tolerant materials. Probably the most moisture intolerant material in a building is paper-faced gypsum wallboard (drywall, sheetrock). The paper on gypsum wallboard is glued to the gypsum using a starch-based adhesive, which quickly grows mold when it becomes wet.

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In areas that can be expected to occasionally become wet such as bathrooms and kitchens, using more moisture-tolerant materials such as fiberglass-faced gypsum board or cement board makes sense. Also, since gypsum board will wick water up, it is a good idea to set the board 3/8 to ½ in. above the floor and then fill the air gap with a moisture -resistant sealant.

7 SOILED DIFFUSERS

You know that black soiling that you sometimes see on the ceiling around ventilation system supply diffusers? Well, it does not mean that you need to clean the ventilation system ducts. What it does mean is that there is a relatively high concentration of airborne particles in the indoor air, most of which are generated indoors. Dirt accumulates on the ceiling by the ventilation system supply diffusers because the supply diffuser air jet causes the laminar boundary layer of air attached to the ceiling to get thinner which increases the deposition rate of particles to the surface. This soiling looks bad and contributes to the occupants' perception of poor IAQ.

The solution is to clean the soiling around the diffusers. To minimize the frequency of reoccurrence, reduce the indoor concentrations of airborne particles by increasing the efficiency of the ventilation system air filters.

8 PARTICLE EMISSIONS FROM VENTILATION SYSTEMS

Another condition that causes occupants to become concerned regarding IAQ is when black particulate matter is emitted from the supply air diffusers such that every morning when you come to work there is a sprinkling of little dark particles on your desk. As your desk is right under a ventilation system supply diffuser, you correctly suspect that the ventilation system is the source of the particles. This is caused by the fiberglass sound liner in the ventilation system, which is old and has become brittle and is shedding small pieces of the black encapsulated fiberglass each morning when the system starts up.

While these particles of sound liner are too large to remain airborne and be inhaled, they do settle onto surfaces where they are unsightly at best and at worst can cause skin irritation. The solution is to replace or repair the degrading sound liner with an encapsulant. In addition, cleaning the ventilation system ductwork of fiberglass particles that have been shed into the system is sometimes required. Changing the ventilation system drive to a VFD and programming it for a soft start also helps reduce the sudden acceleration of the air in the supply ducts on start up, thus reducing the movement of the shed fiberglass particles down the ductwork and out the supply air diffuser.

9 AIR FILTRATION

Keep the ventilation system and cooling coils clean with air filters that have a particle-removal efficiency equal to or greater than MERV 8 as determined by ASHRAE 52.2 and preferably MERV 11 or MERV 13. In areas that EPA has designated as non-attainment areas for ozone (e.g., Los Angeles and Houston areas), ozone that is brought in with the outdoor air can react with indoor air contaminants that are relatively benign, such as terpenes, to produce ultrafine aerosols and aldehydes such as formaldehyde that are potent respiratory irritants.

In these ozone non-attainment areas, having air filters that reduce the concentration of ozone makes sense. Most air filters designed for ventilation systems are designed to remove particles and not gases. Since ozone is such a reactive molecule, some removal can occur in filters designed to remove particles, and work is being done to develop filters with a greater removal efficiency for ozone without producing irritating and unhealthy reaction products. Also, I do not recommend electrostatic air filters as these can produce ozone and the particle removal efficiency can decline significantly with time; I feel similarly about UV irradiation systems, as these systems can produce ozone, and I would suggest they do not provide any significant disinfection of the air and can damage UV sensitive materials.

10 OCCUPANT COMPLAINT/RESPONSE SYSTEM

Last but not least, the lack of a formal system for occupants to register their complaints and concerns with those who control the operation of the building results in either a zero or slow response to mitigate the problem or concerns. This frustrates occupants and makes them angry. Since we do not have *Star Trek* tricorders that can measure all the air contaminants in a building (and even if we did, we don't have the exposure criteria to interpret the data), we must rely on feedback from the occupants regarding the acceptability of the indoor air, and this means facilitating this feedback by having an organized complaint and response plan.

With such a plan, occupants register their complaints/concerns with the facilities management point of contact, the information is logged into a database, and a facilities personnel is dispatched to investigate the complaint. It is also important to dispatch facilities personnel who know something about responding to IAQ complaints and the building and ventilation systems and to do so in a timely fashion.

Building engineers that are Building Operator Certified (BOC) have special training to do this type of occupant complaint response work and can often solve the problem without the need for hiring an indoor air quality consultant (*www.theboc.info*). **ES**

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REFERENCES

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