A comprehensive IAQ management plan should be formulated by designers, contractors, administrators, school staff, and community representatives to anticipate potential IAQ issues and develop cost-effective measures to protect occupants.

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# Maintaining IAQ While Updating Occupied Schools

BY ED LIGHT, MEMBER ASHRAE

Limited available swing space increasingly requires students to remain in a school during construction. This could endanger these students' health because of the airborne contaminants that may result from construction. Careful planning is essential to prevent these hazards. Successful IAQ management also guards against construction delays and the significant cost overruns that can result when IAQ issues become contentious.

Students and staff may be present during construction in these scenarios:

- Renovation is phased by area with adjacent spaces remaining occupied;
- Occupants are moved into one part of newly built school while work is being completed in other areas;
- An addition is built adjoining an occupied structure; or
- Systems are upgraded after hours.

Many school construction projects are developed without a full understanding of potential occupant exposure. While asbestos, when present, is carefully removed in compliance with EPA regulations,[1] control measures are often not specified for other contaminants. A more comprehensive IAQ management plan (*Figure 1*) is best formulated by designers, contractors, administrators, school staff, and community representatives working together to anticipate potential issues and develop cost-effective measures to protect occupants. This process should evaluate each construction step and classify it by relative hazard. While this article focuses on air quality, it should also be recognized that noise and vibration from construction activity are significant factors that must also be addressed in the management plan.

## Options for Preventing Occupant Exposure

Evaluation of each construction task should consider: (a) contaminants emitted by products and

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processes; (b) when and where emissions occur; and (c) exposure pathways (both inside and outside the building). Airborne contaminants can migrate through doors, penetrations, ceiling plenums, and intakes. In addition, settled dust can be tracked around the building.

A variety of strategies may be employed to control contaminant migration into occupied space, including:

- Product/process substitution (i.e., low-VOC products, tools with dust controls);
- Source relocation (i.e., moving tar kettle from intakes);
- Exhaust (i.e., area, point-of-work);
- Air cleaning (i.e., air scrubber filtered to capture dust and odor);
- Control of worker traffic;
- Use of tack mats at exits from dusty areas; and
- Non-occupied buffer zone around work area.

Processes with particularly heavy dust, strong odor, or significant noise may need to be scheduled after-hours to avoid disrupting instruction.

Although dust curtains are often set up around work areas, these may not be sufficient to prevent contaminant migration into occupied space.

For effective work area isolation, the following should be considered:

- HVAC recirculation of air from areas under construction into the occupied space should be avoided. (HVAC should generally be off during demolition, construction and cleanup.)
- All open pathways must be sealed, including penetrations around piping, conduits, etc.
- Pathways above ceilings are particularly challenging, where airflow must be blocked around piping, wiring around structural elements, etc.
- Barriers must be durable. Plastic sheeting alone may be insufficient, and framed, fully sealed wooden barriers may be necessary to ensure control for the duration of the project.
- Barriers should be regularly inspected to ensure their integrity.

Work sites where significant dust and odors will be generated should generally be placed under negative pressure with respect to adjoining occupied or finished spaces. This can be accomplished by exhausting air from construction areas or increasing outside air/reducing exhaust in the occupied space. Care should be taken when modifying site ventilation to avoid back drafting from combustion equipment.

## Roles and Responsibilities

Responsibilities of the various parties should be clearly delineated. Typical roles include:

### General Contractor

- Train supervisory personnel in relevant provisions of the IAQ plan.
- Erect and maintain barriers between work areas and occupied space.
- Identify and seal any penetrations.
- Protect, operate, and maintain HVAC equipment consistent with IAQ plan.
- Regularly inspect work areas to verify that IAQ control measures are being effectively implemented.
- Adjust operations, as needed, to prevent migration of dust and odor into occupied space.
- Respond immediately to any IAQ concerns.

### Facility Management

- Regularly check occupied space for visible dust or detectable odor.
- Immediately report any occupant concerns to the IAQ coordinator.
- Update tenants and their employees regarding site conditions and IAQ controls.

### IAQ Coordinator (Appointed by Either General Contractor or School Administration)

- Conduct periodic walkthroughs of work areas and adjacent occupied space.
- Recognize changing conditions and update IAQ management plan accordingly (especially at the start of each construction phase).
- Investigate and resolve occupant IAQ complaints.
- Recommend HVAC operating procedures to facilitate control of air contaminants.
- Update IAQ status at project meetings.
- Provide information to occupants.
- At substantial completion, perform a general walkthrough of all potentially impacted areas and prepare a punch list for IAQ-related issues.
- Verify the resolution of IAQ punchlist items.

### Staff and School Community

- Promptly report visible dust, detectable odor, or excess moisture.

## Good Housekeeping

Accumulated dust in work areas can be resuspended after initial settling. This is best controlled by minimizing dust generation and frequent cleaning of the worksite. All structural surfaces and contents must be clean prior to re-occupancy. This is facilitated by moving out contents while work is conducted and draping remaining surfaces with plastic sheeting. Final cleaning should generally include HEPA-vacuuming and damp wiping to remove dust.

## Maintaining Building Systems

During construction, HVAC systems need to be protected from contamination in work areas while continuing to provide acceptable conditions in the occupied space. Supply and return vents in work areas should be sealed. The HVAC system should be either shut off in work areas or protected by special filters. In zones where occupied space and construction overlap, recirculation of odor and dust should be prevented by sealing off return systems from the work area. Supply air dampers should generally be closed to prevent pressurization of contained work areas. Because this changes air balance, HVAC fans and dampers may require adjustments to maintain acceptable airflow.

FIGURE 1 Typical IAQ management plan objectives.

- No visible dust or detectable odor related to construction in occupied space.
- Public exposure to construction dust and odors in areas outside the building is minimized.
- HVAC equipment is protected from construction dust.
- Occupant comfort is maintained.
- Acceptable conditions are confirmed prior to occupancy of new areas.
- Occupants are kept informed about the construction process and their concerns are resolved.

During construction, building systems are subject to disruptions in comfort and ventilation, adversely impacting educational activities. Careful planning is needed to minimize these conditions and contingency plans are needed to anticipate changes in HVAC, water, and electrical service.



## Controlling Moisture

Mold growth and dampness in schools are considered unacceptable because they can impact the health of sensitive individuals and cause building damage. Where control measures are not implemented, construction can produce airborne mold, excess humidity, and damp materials.[2-6] Preventative and response measures for these conditions include:

- Identify wet or moldy materials before they are disturbed and ensure remaining surfaces are dried and remediated after demolition.
- Minimize and promptly mitigate envelope or pipe leakage.
- Anticipate and control infiltra-

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tion of surface runoff or groundwater into the building.

- Prevent condensation from forming on pipes, air units, and structural surfaces.
- Avoid excessive humidity.
- Prevent pipe freezing.

## Monitoring

Except for asbestos monitoring during demolition, air sampling for specific contaminants is generally of little value in tracking activities where emissions vary widely in terms of location, timing, and pollutants. Other drawbacks of quantitative air sampling are the time required for documentation and lab analysis and lack of accepted standards for most contaminants.[7]

On the other hand, observations of visible dust, detectable odor, and excessive moisture can be very useful for identifying air quality issues during construction. Project personnel and occupants can continuously check for these conditions and promptly report potential issues. Periodic formal monitoring of work areas and adjacent occupied space should include the same dust, odor and moisture observations, along with verification that specified work practices are being followed (i.e., barrier integrity, pressure relationships). At completion, a final inspection should verify that work areas are in acceptable condition prior to occupancy (i.e., surfaces dry and clean, minimal construction-related odor, systems operating, occupied space isolated from areas with ongoing work).

In some projects, an addition is built that adjoins an occupied structure.

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## Maintaining Communication Between Occupants and Project Management

Occupant awareness of building conditions increases during construction activity. Early involvement of staff and parents, keeping them informed about project details, and providing opportunities for their input, is critical for successful IAQ management.[8] Prompt response to complaints is important for occupant acceptance of the temporary inconveniences posed by construction. It is often helpful to create a committee representing staff and parents that meets regularly with project management to review progress and issues as the work evolves. A chain of command should also be established for processing complaints. Occupants should be encouraged to report concerns, especially when they observe settled dust, visible haze, detectable odor, and excess moisture. Such issues

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should be resolved quickly and clearly communicated back to complainants.

## Case Examples

### Phased School Renovation

An older school was scheduled for major structural renovation and systems replacement. Work was to be performed in a quarter of the building at a time, with occupants from each construction area relocated to portable classrooms. IAQ controls were initially limited to dust barriers.

Staff and students complained of visible haze, settled dust, and construction odors. When some staff members attributed respiratory symptoms to construction exposure, work was stopped pending review of site conditions and implementation of more effective controls.

An assessment found the following:

- Diesel-fired generators were located near unit ventilator intakes.
- Adhesive, enamel paint, and roofing odors were migrating into the occupied space.
- Dust was being generated by saw cutting, wall demolition, excavation, and resuspension of accumulated debris.
- Barriers did not extend above suspended ceilings, and penetrations were not sealed.

The following additional controls were then implemented:

- Extended fully sealed barriers from floor to decking.
- Moved generators away from intakes.
- Operated exhaust fans in work area and increased outdoor supply air to occupied zones.
- Cleaned up dust and debris in work areas daily.
- Placed tack mats at entrances to occupied areas and restrict traffic.
- Deferred saw cutting to after-hours.

These changes resolved occupant complaints and work proceeded on schedule.

### HVAC Zones Overlap Occupied Space & Work Areas

Rooftop unit zones overlapped occupied and construction areas during a phased structural/mechanical renovation. Openings between these areas were generally sealed with plastic, and portable fans were exhausted to

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the outside from some construction areas. Return air vents in work areas were sealed and heavy demolition work was scheduled after-hours.

Despite precautions, some staff observed accumulating dust and detected construction odors in adjacent classrooms. An investigation found:

- Main supply air ducts into construction areas were left open to maintain system balance, but this pressurized construction areas relative to occupied space.
- Barriers protecting occupied areas were incomplete, allowing construction air to migrate through above-ceiling plenums and open pipe penetrations.

These problems were resolved by:

- Capping off supply ducts in the construction area and reducing fan speed to maintain static pressure in the occupied space.
- Fully sealing openings and penetrations.

### After-Hours Replacement of Moldy Chilled Water Pipe Insulation

Widespread mold growth was found on chilled water pipe insulation due to years of sweating. Insulation replacement was scheduled to be done by area overnight. Project specifications including the following measures to protect occupants:

- Staff were kept informed, and teachers in classrooms scheduled for work were given the opportunity to move their contents away from areas that were under piping, with the assistance of custodians.
- Surfaces under work areas were covered by plastic sheeting and critical barriers were placed on doors to adjacent areas.
- Nightly contractor work was not considered complete until the school's consultant confirmed that the area was remediated and cleaned, and that all new insulation was fully sealed.

The project was completed without incident.

## SMACNA Guidelines

Based on the author's experience managing school construction as a consultant to school districts, U.S. guidelines for occupied building construction were developed.[9] Discussion in this article has been limited to a general overview of IAQ management during construction in occupied buildings, and readers are directed to the SMACNA document for more detailed information and specific recommendations. This manual includes background information and guidance for project planning, control options, site management, monitoring, communication between parties, re-occupancy criteria, and example specification.

## Summary

During occupied school construction, staff and students are at risk for exposure to harmful contaminants, and projects are subject to delays and even shut downs when conflicts develop. These delays and unanticipated costs can be avoided through effective planning and implementation of an IAQ management plan. IAQ controls should be integrated into the construction planning process from the beginning. Additional costs are minimal where cost-effective control strategies are used. Implementation of work practices and site conditions should be monitored continuously. Occupants concerns are best resolved where they are kept fully informed and involved in the process.

Evaluation of each construction tasks should consider contaminants emitted by products and processes, when and where emissions occur, and exposure pathways (both inside and outside the building).

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