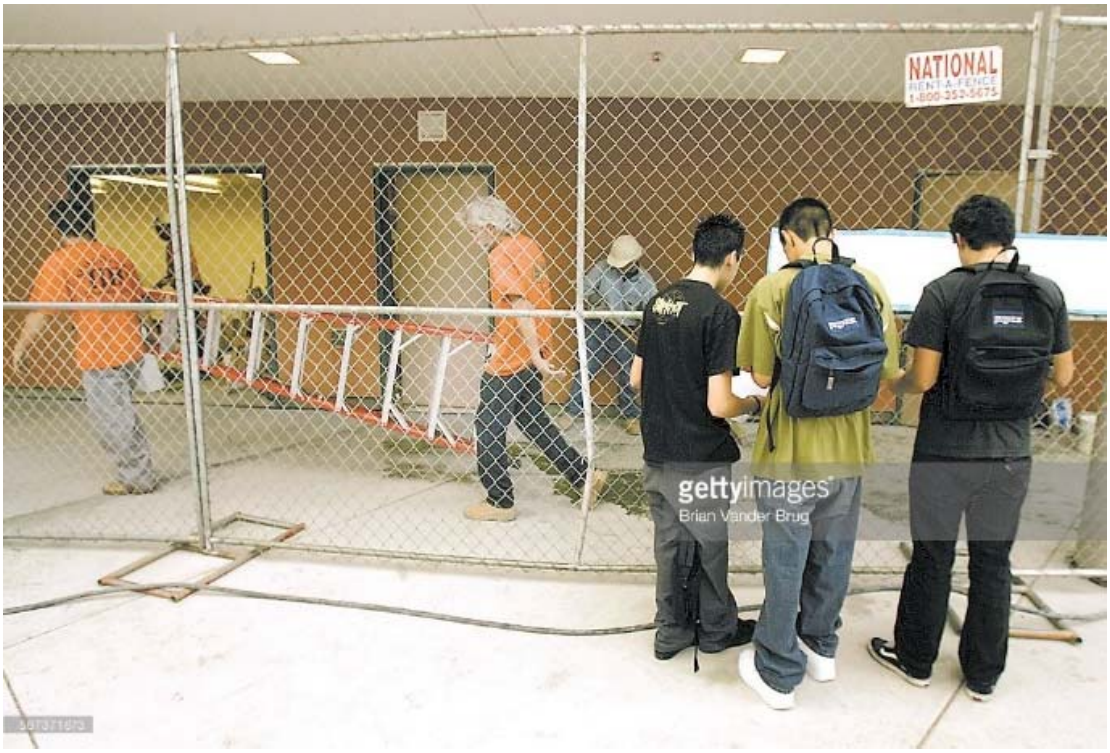

Can Occupied Schools be Modernized while Maintaining Acceptable IAQ?

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Airborne contaminants associated with school construction can present serious health risks for occupants. With limited swing-space available during school modernization, students and staff increasingly remain in schools while:

- **Renovation is phased by area, while adjacent space remains occupied;**
- **Occupants are moved into a newly built school with work being completed in other areas;**
- **An addition is built adjoining an occupied structure; or**
- **Systems are upgraded after-hours.**

Without careful planning and effective management, school modernization may produce hazardous conditions for occupants, disrupting construction and leading to delays and significant cost overruns.

This paper is based on the author's experience planning and managing school construction as a consultant to school districts and developing U.S. guidelines for occupied building construction (SMACNA, 20116).

Photo 1. Contaminants from construction areas can have serious health consequences

Planning for many school construction projects does not include a comprehensive assessment of potential occupant exposure. Although asbestos, when present, is generally removed under controlled conditions in compliance with EPA regulations, effective control measures are often not specified for other contaminants. After the scope of a school modernization project is proposed, designers, contractors, administrators, school staff and community representatives should, together, anticipate potential issues and formulate an IAQ management plan (figure 1) for preventing or resolving these problems. This process should evaluate each construction step, and classify it by degree of hazard and the probability it could impact occupied space.

Figure 1. Typical IAQ Management Plan Objectives**.**

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

Options for preventing occupant exposure.

Task analysis should consider: (a) contaminants emitted by products and 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. Dust can also be tracked around the building.

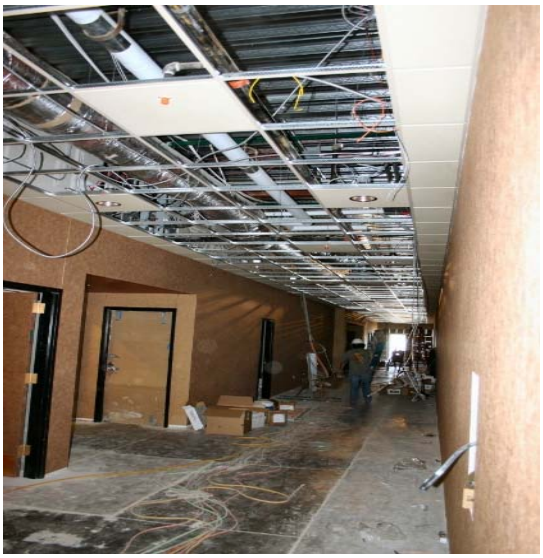

Photo 2. Pathways from work areas include openings, penetrations, air intakes and foot tracking

A variety of strategies may then 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)
- Local exhausts
- Control of worker traffic
- Tack-Mats leaving dusty areas
- Non-occupied buffer zone around work area

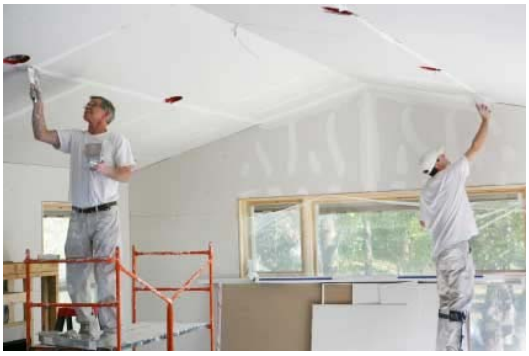

Photo 3. Substituting low-VOC paint reduces odor in occupied space.

Although dust curtains are often set up around work areas, these may not be sufficient to eliminate contaminant migration into occupied space. For effective work area isolation, the following should be considered:

- All open pathways must be sealed, including penetrations around piping, conduits, etc.

- Pathways above ceilings are particularly challenging, where air flow must be blocked around piping, wiring around structural elements, etc.
- Work area depressurization may be needed to protect occupants (i.e., exhausting air outside from the contaminant, increasing outside air to occupied space).
- 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.

Photo 4. Dust curtains may be insufficient to prevent contaminant migration.

Processes with particularly heavy dust, strong odor or significant noise may need to be scheduled after-hours to ensure occupant protection.

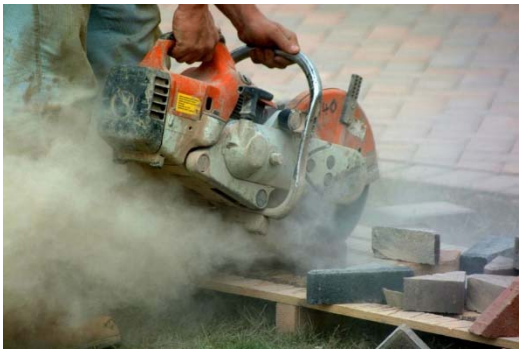

Photo 5. Construction tasks with the heaviest emissions may need to be restricted to after-hours.

Good Housekeeping.

Accumulated dust in work areas can be re-suspended, contaminating occupied space. This is best controlled by minimizing dust and frequent cleaning of the work-site. Before re-occupancy, all structural surfaces and contents must be clean. This is facilitated by moving out contents, to the extent feasible, and then draping remaining surfaces with plastic sheeting. Final cleaning should access all surfaces and include HEPA-vacuuming to remove particulate and sanitizing where mold growth has been disturbed.

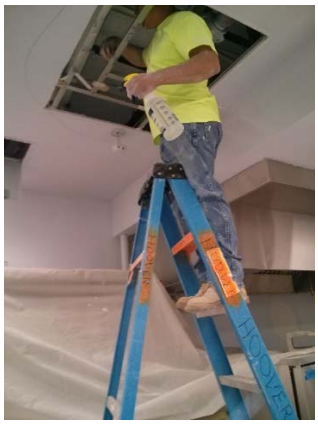

Photo 6. Cleaning construction dust above the ceiling.

Maintaining Building Systems.

During construction, HVAC systems need to be protected from contamination in work areas while maintaining operations in occupied space. Supply and return vents in both ducts and air units should be sealed. HVAC should be either shut off in work areas or, if needed, protected by special filters and kept pipes from freezing. 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 (maintaining negative pressure helps control contaminants). Because this changes air balance, HVAC fans and dampers may then to be adjusted to maintain acceptable air flow.

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

Photo 7. Air supply and return systems work areas should be sealed off from occupied space.

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. Preventative and response measures for these conditions include:

(a) Identify wet or moldy materials before disturbance and dry or remediate remaining surfaces after demolition.
(b) Prevent or immediately correct leakage through exterior openings and penetrations.
(c) Anticipate and control infiltration of surface runoff or ground water into the building.
(d) Ensure condensate drains properly from cooling coils.
(e) Avoid excessive humidity.
(f) Prevent pipe freezing.

Photo 8. Excess moisture during construction can leave mold growth.

Monitoring

The most critical IAQ parameters to monitor during construction for managing IAQ are visible dust, detectable odor and excessive moisture. Sampling for specific contaminants is generally of little value because emissions vary widely in terms of type, timing and location (asbestos monitoring during demolition is an exception to this). Both project personnel and occupants can continuously check for visible dust, detectable odor and excess moisture and report suspect situations to the designated IAQ coordinator for investigation. In addition, a inspection of work areas and adjacent occupied space should be conducted periodically to verify that specified work practices are being followed (i.e., barrier integrity, pressure relationships, designated tasks delayed to after-hours). 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).

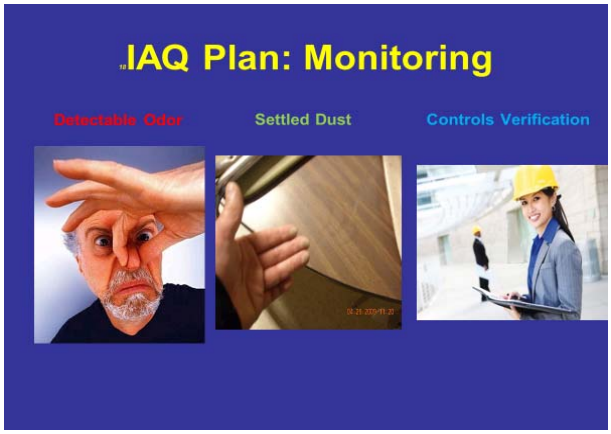

Photo 9. General observations rather than pollutant measures are most effective for IAQ protection.

Maintaining communication between occupants and project management.

Occupants are often highly concerned about construction activity in their school. Early involvement of staff and parents, keeping them informed about project details and providing opportunities for their input, is important for successful IAQ management. Prompt response to complaints is important for occupant acceptance of the temporary inconveniences posed by construction. It is often helpful to designate a committee representing staff and parents to meet regularly with project management to review progress and issues as the work evolves. A chain-of-command should also be established to receive and process complaints. Occupants should be encouraged to report concerns, especially observation of settled dust, visible haze, detectable odor and excess moisture. Such issues should be resolved as soon as possible and clearly communicated back to complainants.

Photo 10. Construction managers meet with staff and parents.

Roles and Responsibilities.

During the planning phase, responsibilities of the various parties should be clearly delineated. Typical roles include:

General Contractor.

- 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
- Adjust operations, as needed, to prevent migration of dust and odor into occupied space
- Regularly inspect work areas to verify that IAQ control measures are being effectively implemented
- Respond immediately to any IAQ concerns
- Train supervisory personnel in relevant provisions of the IAQ Plan.

Facility Management.

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

IAQ Coordinator *(appointed by either GC or school administration).*

- Conduct periodic walkthroughs of work areas and adjacent occupied space
- Discuss changed conditions or new issues related to construction IAQ with project personnel.
- Investigate occupant IAQ complaints and recommend response measures
- Recommend HVAC operating procedures to facilitate control of air contaminants
- Present IAQ update at project meetings
- Provide information to occupants
- Identify potential IAQ issues at the start of each new construction phase and update IAQ Plan, as needed
- 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 punch list items.

Staff and School Community.

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

Pre-Occupancy Assessment.

Prior to occupancy of newly constructed areas, it should be determined that surfaces are mold free, dry free of visible dust, new material odors are minor and diminishing, occupied areas will continue to be isolated from ongoing construction and HVAC systems are functional. Any deficiencies noted can be included in the punch list (to be resolved prior to acceptance).

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 portables. 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

Assessment findings:

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

The following additional controls were then implemented:

- Extend fully sealed barriers from floor to decking,
- Move generators away from intakes.
- Operate exhaust fans in work area and increase outside supply air to occupied zones.
- Clean up dust and debris in work areas daily.
- Place tack mats at entrances to occupied areas and restrict traffic.
- Defer saw cutting to after-hours.

These changes resolved occupant complaints and work proceeded on schedule.

<u>HVAC zones overlap occupied space and work areas.</u>

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

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

- Work areas were positively pressurized to occupied space.
- Main supply air ducts into construction areas were left open at the ends 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 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 over weekends. 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 from areas under piping assisted by custodians.
- Surfaces under work areas were covered by plastic sheeting and critical barriers were placed on doors to adjacent areas.
- Contractor's 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

Comprehensive guidance for managing construction in occupied structures is available from SMACNA: IAQ Guidelines for Occupied Buildings Under Construction (ANSI/SMACNA 008-2008) https://www.smacna.org/store. This manual includes background information and provides voluntary guidance for project planning, control options, site management, monitoring, communication between parties, re-occupancy criteria and a model specification.

Summary

During occupied school construction, staff and students are at risk for exposure to harmful contaminants. Consequently, these project 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. Additional costs are minimal where cost-effective control strategies are utilized and IAQ controls should be integrated into the construction planning process from the beginning. Implementation should be monitored continuously. Occupants concerns are best resolved where they are kept fully informed and involved in the process.

Reference

SMACNA (2005)….

Acknowledgements:

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