

WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Maintaining Acceptable Indoor Environmental Quality (IEQ) During Construction and Renovation Projects

Summary

The National Institute for Occupational Safety and Health (NIOSH) has conducted several Health Hazard Evaluations [NIOSH 2019] in workplaces with reported health concerns associated with construction and renovation in occupied buildings. During these evaluations, NIOSH investigators identified issues that could affect indoor environmental quality (IEQ) such as a lack of dust control, the use of high emission building materials, and limited communication with occupants about hazards related to the work being done. After its evaluations, NIOSH made detailed recommendations to help employers reduce exposures and maintain acceptable IEQ.

Background

Activities during construction, renovation, demolition, or repair projects can release airborne dusts, gases,

organic vapors, microbiological contaminants, and odors as well as produce high noise levels [ANSI/SMACNA 2007; EPA 2019; Kuehn 1996; Light 2017]. In addition, outdoor air contaminants can be brought into the workplace.

When workers occupy spaces adjacent to these construction projects, the activities can trigger health complaints [Abdel Hameed et al. 2004; Ward et al. 2017]. Common symptoms reported by building occupants during these projects include headache, sinus problems, congestion, dizziness, nausea, fatigue, and irritation of the eyes, nose, or throat. These symptoms may result from exposures to known agents or a perceived risk from exposure to unknown agents [Kuehn 1996]. Kurth et al. [2017] found an association linking exposures to mold, dampness, and construction materials to asthma and asthma-like symptoms.

Foresight and planning are necessary to reduce IEQ-related symptoms during building construction activities. Management strategies to reduce and control building occupant exposures should include the following:

1. Ensuring that construction contractors understand and are aware of the potential impact of construction and renovation activities on building occupants
2. Anticipating construction and renovation activities that may generate contaminants
3. Implementing controls to minimize exposures of both construction workers as well as building occupants

Case Studies

The following case studies demonstrate issues that NIOSH frequently encounters during IEQ investigations and provide recommendations that can improve the facility IEQ.

Case Study 1

NIOSH visited an office building undergoing a multi-year modernization project. The project included these changes:

1. Upgrading the heating, ventilation, and air-conditioning (HVAC) systems



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2. Improving the plumbing, electrical, and fire protection systems; and removing asbestos-containing material and lead-based paint
3. Structure modifications such as new stairways in six building wings

Employees from the building wing undergoing renovation were temporarily moved to an adjacent wing. All of the adjacent wings remained occupied during renovation. Employees working in these wings reported dustiness, odors, eye and upper respiratory irritation, and asthma and allergy symptoms.

Using sulfur hexafluoride tracer gas to study air movement in the building, NIOSH investigators found that air flowed from the areas undergoing construction into the adjacent occupied office areas. Routes for the potentially contaminated airflow included areas around polyethylene-sheet barricades that were poorly sealed, holes in the ceiling where lights had been removed, holes in the wall board, and holes in the terra cotta blocks behind the baseboards. In addition, temporary seals over the hallway return air ducts had become loose, allowing potentially contaminated air to enter into the ventilation systems. Workers were also dry sweeping construction debris, which produced airborne dust.

NIOSH investigators recommended that the employer take the following measures to limit contaminated airflow into occupied areas [NIOSH 2007]:

1. Install and maintain construction walls and barricades and additional ventilation to keep the renovation and construction areas under negative air pressure relative to the occupied office area.
2. Use vacuum cleaners equipped with high efficiency particulate air (HEPA) filters to clean up dust and debris.
3. Completely cover all HVAC supply and return air grills in the construction area and surrounding hallways to prevent contaminants from entering the HVAC systems.
4. Communicate regularly with building occupants about the on-going construction work to minimize anxiety among the employees.

Case Study 2

NIOSH evaluated a school that had undergone recent renovations, including the addition of administrative space, library, classrooms, ventilation systems, electrical wiring, plumbing, and communications systems. The original brick school was built in the early 1960s with a crawl space, which had a dirt floor and a partial moisture barrier. The school was commissioned, which verified new systems were operating according to design before reopening. Employees were concerned about mold exposure in the newly renovated areas.

NIOSH investigators found that air flowed from the crawl space into the school because the exhaust fan in the crawl space did not work and was undersized for the area. The nearby ground sloped toward the building, which allowed surface water to enter into the crawl space. Relative humidity levels were higher in the crawl space than in the school building. Visible rust was present on all of the metal beams in the crawl space, indicating that the space had high moisture levels. Wipe samples taken from the new part of the school had lower fungal spore concentrations overall than those from the first floor of the renovated part. This indicated that there was much less mold contamination in the new part of the school. Carbon dioxide monitoring showed that the variable air volume control box for one classroom was not functioning correctly, which reduced the amount of outdoor air entering the space. School staff reported sinus problems and headaches that they thought were related to working in the school.

NIOSH recommendations to reduce moisture incursion into the building included the following [NIOSH 2011]:

1. Maintain negative pressure in the crawl space with a properly working exhaust fan that is correctly sized for the volume to be controlled.
2. Add a complete moisture barrier to the crawl space.
3. Seal the floor penetrations.
4. Test and balancing the variable air volume ventilation system to ensure adequate ventilation in all occupied areas.
5. Re-grade the soil around the building to move surface water away from the building.

Recommendations

The following recommendations for maintaining acceptable IEQ during construction and renovation projects were developed based on NIOSH experiences from IEQ site visits and review of the scientific literature. Maintaining acceptable IEQ during construction and renovation activities requires a collective effort and input from building managers, the general contractor, subcontractors, engineers, and building occupants [ANSI/SMACNA 2007; ASHRAE 2009; EPA 2019]. Other federal agencies have specific mandatory standards and rules that need to be followed to protect the workforce and building occupants. The Occupational Safety and Health Administration (OSHA) has specific standards that address asbestos and lead hazards. EPA has two specific asbestos guidelines for schools: Asbestos Hazard Emergency Response Act (AHERA), and building demolition and renovation Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP).

Input from HVAC professionals is important to assess ventilation system performance when making design changes or

when making temporary modifications of the HVAC system during construction and renovation. Effective communication among all parties is essential, especially during rapidly changing circumstances, which are often a hallmark of construction and renovation activities. Several states have created guidelines for building renovations, especially schools [California Department of Education 2018; see ELI 2015 for additional state guidelines].

Implementing the recommendations below should reduce building occupant exposures. Protective measures should be considered according to the NIOSH [2015] hierarchy of controls, with an emphasis on controlling the hazard at the source if it is not possible to eliminate the hazard.

Initial Planning

The initial stage of any construction or renovation activity is the appropriate time to develop a site- and activity-specific plan to identify and control contaminants that may affect construction or renovation workers as well as building occupants.

- Identify all key personnel, such as representatives from the building and general contractor responsible for addressing construction- or renovation-related activities and airborne contaminant control, as well as other personnel such as building staff, engineers, and subcontractors. Engage these key personnel in the initial planning of the construction or renovation.
- Conduct an assessment of hazardous substances present in the building such as asbestos and lead.
- Develop a construction or renovation impact assessment with input from key personnel describing anticipated work activities along with their associated air contaminants, generation points, and areas potentially affected by the release of air contaminants.
- Develop a detailed plan and budget for the contaminant control methods that will be used.

Contract Bid Specifications

Bid specifications should be developed. In addition to general control measures detailed below, the bid specifications should include details about the control measures appropriate for the construction or renovation project being proposed. These bid specifications should be clearly written and include the elements below to reduce misinterpretation.

- Identify and provide details about the specific controls needed to reduce the release of contaminants into occupied areas during the construction or renovation project, including appropriate performance metrics.
- Require the general contractor to designate an IEQ manager and establish appropriate channels of communication

with subcontractors. The IEQ manager should be trained on IEQ issues, such as air quality, acoustics, lighting, and temperature control, and have the authority to immediately correct problems.

- Require training for construction employees on hazards and proper PPE usage (Figure 1). For construction training specifications, see the OSHA construction industry website.
- Develop emergency response procedures and specify conditions that would require an emergency response (such as a contaminant release into an occupied area).



Photo by EPA

Figure 1. Worker wearing PPE during mold removal.

Control Options

Strategies should be developed to address the specific tasks and building configurations as well as control of both indoor- and outdoor-generated contaminants. Some general considerations for control include the following:

- Schedule construction or renovation work during periods of low building occupancy and low occupancy adjacent to the work areas whenever possible.
- Isolate work areas from occupied areas using physical barriers, negative pressurization of the construction or renovation area relative to occupied areas, and use HEPA filtration to remove particulates (Figures 2 and 3). Techniques include the use of vestibules, double-doors, or air curtains as ways to prevent air movement through doorways. If the work area is large, a positive pressure buffer zone can be created between the work area and occupied area if there are no hazardous substances (such as asbestos) present that require negative pressure controls.
- Use local exhaust ventilation with HEPA filtration where dust generation is anticipated. If local exhaust is not feasible, portable air cleaning devices could be used.

- Minimize the number of building penetrations [ANSI/ASHRAE 2019].
- Modify HVAC operations as necessary during times of construction or renovation activities to ensure areas are kept isolated from occupied areas. This could include increasing the HVAC outdoor air intake filtration efficiency and temporarily relocating the intakes serving the occupied areas.
- Maintain an adequate unoccupied buffer zone around the work areas to allow for construction or renovation traffic. This could require temporarily relocating building occupants away from the immediate vicinity of the work areas.
- Post warning signs on barricades, construction zones, and other areas limiting access to authorized personnel only.
- Increase housekeeping activities in adjacent occupied areas during construction or renovation projects.
- To reduce the likelihood of contaminant generation, specify low-emitting materials for use in construction or renovation projects such as those listed in EPA's Safer Choice Program [EPA 2019].



Photo by EPA

Figure 2. Covered entryway to prevent dust from leaving construction and renovation areas.

Protect HVAC Systems

Protect the HVAC system(s) serving the construction or renovation areas from damage or contamination.

- Disable and isolate the portions of the HVAC system(s) serving the construction or renovation areas to prevent damage or contamination, if possible.
- Block or seal supply and return air grilles in construction or renovation areas.

- Upgrade the filtration efficiency of any HVAC systems serving occupied areas that must continue to be in use during construction or renovation activities to the highest level supported by the building HVAC systems. Inspect and replace filters as needed.
- Designate a storage location for construction materials and equipment to reduce the potential for contaminants to enter occupied areas. Do not store construction materials or equipment in HVAC mechanical rooms.

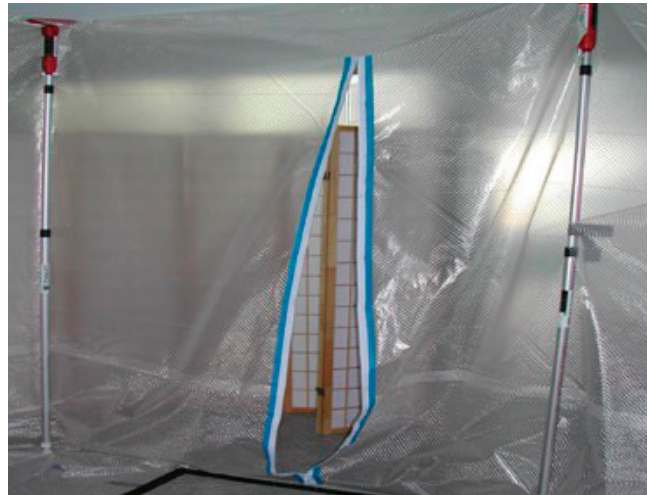


Photo by EPA

Figure 3. Full containment during renovation project.

Implement Project Specifications

Effective implementation and management of the construction or renovation project is essential to maintain acceptable IEQ for the building occupants [ASHRAE 2009].

- Hold regularly scheduled meetings between building representatives, the general contractor, subcontractors, and other personnel as appropriate to ensure the acceptability of IEQ. The code for this document is 373364
- Monitor construction or renovation activities carefully so that all work conforms to the bid document specifications.
- Monitor the pressurization of both construction or renovation and occupied areas to ensure that isolation of the work area is maintained.
- Monitor for airborne contaminants, such as particulates or volatile organic compounds, in the occupied areas to ensure acceptable IEQ.

Good Work Practices by Construction Workers

Good work practices and housekeeping that minimize contaminant release are essential for ensuring acceptable IEQ in employee-occupied areas during construction or renovation

projects. Workers in the construction areas should use the following practices to reduce exposures.

- Use work practices and materials that result in little or no generation of airborne contaminants during construction or renovation activities, such as wet methods to suppress dust generation as well as paint and carpeting with low volatile organic compound emissions.
- Establish routes for construction or renovation traffic to pass through unoccupied areas. Do not permit construction or renovation traffic to pass through occupied areas or common building openings.
- Use vacuums with HEPA filtration and damp mop regularly during construction or renovation activities to reduce dust generation.
- Bag all construction or renovation debris, and promptly remove debris from the work site through demolition chutes on the exterior of building and/or other dedicated perimeter wall openings.
- Locate dumpsters and salvage bins away from HVAC outdoor air intakes and exterior doors and windows to occupied areas.

Maintain Effective Communication

Ensure that the project manager, general contractor, sub-contractors, and other personnel effectively communicate among themselves and with building occupants throughout construction or renovation.

- Before the start of construction or renovation activities, communicate to building occupants the scope of work and the precautions that will be used to control the release of contaminants.
- During the construction or renovation project, periodically update building occupants regarding the project's progress and other pertinent information.
- Promptly respond to complaints from building occupants regarding construction- or renovation-related IEQ issues and identify any situations that would require emergency response.
- Instruct building occupants to inform their supervisor and seek medical care if they develop health symptoms that they think are related to construction- or renovation-related IEQ issues.

Commission Work Areas after Completion of Construction or Renovation

- If possible, use 100% outdoor air to ventilate the work areas prior to occupancy to ensure acceptable air quality.
- Ensure the HVAC system(s) in the work areas are tested and balanced before re-occupancy.

- Monitor for airborne contaminants, such as particulates or volatile organic compounds, in the work areas to ensure acceptable IEQ when re-occupied.

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For More Information

For more information about indoor environmental quality and preventing exposure during construction, visit <https://www.cdc.gov/niosh/topics/indoorenv/constructionieq.html>.

For more information about the NIOSH Health Hazard Evaluation Program, visit [cdc.gov/niosh/hhe/default.html](https://www.cdc.gov/niosh/hhe/default.html)

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