City of Biddeford

Facilities Department & Environmental Code Office
205 Main Street • P.O. Box 586 • Biddeford, ME 04005

IAQ Construction Control Guide

2016

Revision 3

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Appendices

1.0 Introduction & Purpose

The purpose of this guidance document is to control construction contaminants to reduce possible impacts to building occupants. The guide is based on the principles and practices developed by the Sheet Metal and Air Conditioning Contractors' National Association, Inc., as published in *IAQ Guidelines for Occupied Buildings Under Construction.*

The primary objective of the guidance document is to establish a framework for identifying potential indoor air quality (IAQ) issues associated with construction activity, evaluating potential impacts, developing strategies to mitigate potential IAQ impacts, and documenting and monitoring effectiveness of strategies, in order to conduct construction activity without affecting IAQ in occupied areas.

Poor indoor air quality (IAQ) is more likely to affect the health of building occupants when construction and renovation projects occur in an occupied building. Dust and odors or other contaminants of concern migrating out of the work area and into occupied spaces can disrupt normal operation of the facility and, under worst-case scenarios, cause injury or illness. While IAQ concerns in most buildings are often comfort issues, environmental changes in occupied buildings undergoing construction can result in actual and perceived adverse effects. The mere presence of detectable dust or odor from a construction project, even at harmless levels, may trigger occupant concerns based on perceived hazards.

Effective management of IAQ construction requires all parties (designers, contractors, facility managers, building engineers, and the occupants) to plan and work together.

Design of interior construction projects should include a detailed assessment of HVAC systems and relative pressurization, including their relationship to the proposed work. Where steps must be taken to protect building occupants from construction emissions, modifying HVAC operation and protecting the HVAC equipment and air conveyance system are often integral parts of the process.

Standards for non-occupational air quality are not defined by either OSHA or EPA. In practice, however, IAQ controls are usually based on common sense and good professional judgment. Ongoing documentation of these decisions is necessary to ensure effective project completion. Even where the best IAQ controls are in place, clear communication between all parties and flexibility to adapt to changing conditions are required for successful resolution of problems.

This guide will focus on those activities that temporarily produce airborne dust, odor, and other contaminants during demolition, construction, and punch list activities.

This guide presents generalized options available to help resolve common construction related IAQ problems, and as such, it is not intended to cover all construction processes and pollutants.

This guide does not address worker protection at the construction job site. Compliance with OSHA standards or other applicable requirements on safety, workplace exposure to airborne contaminants, etc., is the responsibility of the contractor.

2.0 Project Management

2.1 Organization

2.1.1 Responsibilities

All members of the project team should have defined responsibilities regarding IAQ. Regular project meetings should be scheduled to address the status of IAQ issues. Project-specific responsibilities and meeting schedules are addressed in specific contract documents.

Contractors and other workers from the construction trades must be briefed as to the measures taken to protect IAQ and how these measures will be enforced at each stage of the project. Foremen should have a complete knowledge of containment procedures and other specific tools, practices, and controls as well as back-up contingency plans to be implemented in the event of a problem. They are responsible for having their workers effectively implement the IAQ plan.

2.1.2 Pre-Renovation Planning

A pro-active renovation program will identify airborne contaminants likely to be present during the project. A baseline survey of the building environment and HVAC systems, based on existing plans and conditions will be used to develop an IAQ management plan for each phase of the work. Each phase of work can then be categorized as to potential risks from the type and amount of contaminants present, proximity to occupants, and the availability of controls.

Once the basic task specific specifications have been proposed, an additional field inspection will be performed to identify hazardous materials for special handling, critical pathways through which contaminants could move into occupied space and available control options.

The containment evaluation will include a final review by the project team to integrate these indoor environmental concerns into the overall project, balancing costs, owner and occupant needs, and construction logistics. Schedules must ensure that activities are performed in proper sequence to facilitate the control of potentially airborne contaminants in the most cost-effective manner. Sufficient time should be allotted to allow for effective HVAC system testing, adjusting, and balance and other commissioning procedures.

2.1.3 Continuous Review

Maintaining acceptable IAQ during renovation is as much a management challenge as a technical issue. Leadership by facility management or the project manager is crucial to the achievement of the goal. Continuous feedback is also needed throughout the project to help assess the effectiveness of IAQ controls.

2.2 Selecting IAQ Controls

Most projects require site-specific determinations as to what, if any, IAQ controls are needed. The selection of IAQ controls should be developed from the following process:

Step 1: Identify all potential sources of dust and odors or other contaminants of concern. This should include all aspects of the job, from initial site preparation to final punch list with a focus on the following:

- All existing building materials which will be disturbed, including visible microbial growth, chemical contamination, and asbestos or lead-based materials
- Any product or activity which may create dust and odors or other contaminants of concern during the construction or clean-up process *(Note: appropriate precautions must accompany work with products labeled "use adequate ventilation" or "use only outdoors or in a well ventilated space", etc.)*
- Any equipment which will produce combustion products or other detectable emissions
- Adverse conditions which could result from the disruption of existing building systems (*e.g.,* sewer gas, discharge of particulates from ductwork, thermal discomfort)
- Waste material handled or stored at the site

Step 2: Locate occupied areas potentially affected by the project. This requires knowledge of:

- Times when specific building areas will be used by occupants
- HVAC zones receiving re-circulated air from construction site
- Areas adjacent to sources of dust and odors or other contaminants of concern
- Other potential pathways (*e.g.,* stairwells air plenums or shafts or elevator shafts)
- Areas likely to include hypersensitive occupants such as immune compromised or severely asthmatic individuals

Step 3: Identify construction activities likely to produce detectable odor or dust in occupied areas. Based on the results of Steps #1 and #2, identify construction activities and sources that will actually be detectable in critical areas.

Step 4: Classify potential IAQ problems by relative risk. To simplify evaluation, similar sources may be composited (*e.g.,* the application of various paints and glues may present similar odor control issues unless one work area is close to hypersensitive occupants). Worst-case scenarios should generally be assumed when evaluating potential hazards (controls should then be effective for the full range of operating conditions). Based on available information, classify dust and odors or other contaminants of concern using one of three categories signifying the relative degree of hazard:

Class 1: These are air pollutants expected to have only a nuisance impact on exposed occupants. Health effects rarely occur except in the case of hypersensitive individuals. An example is a small-scale wall relocation that will produce only small amounts of dust not containing an action level of asbestos or lead-based paint.

Class 2: These are air pollutants which could cause a moderate but temporary health impact on some occupants if not controlled. An example is removal of localized moldy material or replacement of multiple walls, ceilings, or floor coverings.

Class 3: These are potentially hazardous air pollutants which could cause severe, acute, or chronic illness. Examples include disturbance of asbestos fibers, heating of roof tar, application of enamel paint, mixing of epoxy resins, non-vented operation of gasoline or diesel-powered equipment, and dust from lead-based paint.

Step 5: Identify available control options. Select measures designed to minimize the release of dust and odors or other contaminants of concern into occupied areas. The stringency of control required should be

based on the above hazard classifications (maximum control needed for Class 3, etc.). All available controls should be considered for planning purposes, including:

- Protection of HVAC systems including use of temporary heating/cooling equipment
- Substitution of lower emitting products
- Modification of equipment for capturing or lower emissions
- Air cleaning
- Covering or sealing emissions
- Pressurizing occupied space
- Depressurizing construction areas with local exhaust
- Erecting barriers
- Controlling moisture
- Remediating mold
- relocating sources
- Temporarily sealing off outside sources
- Suppressing or capturing dust at the source
- Increasing cleaning frequency or efficiency
- Vacating buffer zone around work sites
- Restricting work to off-hours
- Moving hypersensitive individuals

Disturbing regulated materials, such as asbestos or lead-based paint, may require additional attention due to specific legal requirements.

Step 6: Select specific control measures. Select measures sufficient to meet the project IAQ objectives in keeping with the degree of hazard involved. IAQ controls must be compatible with the project budget and facility operational requirements. Final selection will be based on the most efficient approach which will adequately protect the occupants. In some cases, the size or location of work areas may need to be modified or sequentially staged for optimum environmental control.

3.0 Control Measures

3.1 Overview

A variety of control strategies are available to maintain IAQ during construction or demolition in an occupied building. The pros, cons, and limitations of viable strategies will be considered when identifying the most effective and efficient approaches for the project. In general, the choices involve:

- Protecting HVAC systems, *e.g.*, prohibit use of permanent HVAC systems during demolition;
- Controlling the source;
- Interrupting pathways;
- Intensifying housekeeping; or
- Rescheduling work hours.

Projects typically use more than one of these measures, with evolving control strategies as the project phase progresses.

3.2 HVAC Protection

All HVAC equipment must be protected from collecting not only dust but also odors or other contaminants of concern which can "stick" to both porous and non-porous materials in the system and later be released. Use of permanent HVAC equipment in construction areas is prohibited, *see* Section 4.3. The design of each system must be evaluated in detail to determine how it may be affected by dust and odors or other contaminants of concern from the project including site egress, staging areas, etc. Specific HVAC protection requirements generally apply to the return side, central filtration, or supply side of the system. Control of building pressurization is an important issue associated with HVAC during construction (*see* discussion in section 4).

3.3 Source Control

The most effective type of pollution control is generally at the source. A variety of options are available depending on the type of products and equipment needed for a given project. Costs are site-specific. Where more than one control option is feasible, costs will be compared in the selection process.

3.3.1 Product Substitution

In response to IAQ concerns, many manufacturers have formulated lower emitting products. The advantage of low-solvent-emitting products may be only short-term since off-gassing from conventional products may diminish within a few weeks. Selection of low-emitting products should conform to project specifications, but may be changed based on the results of the IAQ impact review process.

The use of products emitting lower amounts of odor and VOCs may not be critical if the work area is isolated from building occupants and the space will be ventilated for several days before re-occupancy. The advantages of lower emitting products are most evident under the following circumstances:

- Occupants are nearby while product is being applied or installed;
- Odor pathways exist from the work area to occupant space; and,
- Re-occupancy of the work area must occur very quickly, leaving insufficient time for the materials to off-gas.

Specific product substitutions may be appropriate based on physical properties of products if not already specified. For example, consider cement board instead of paper-covered sheetrock in damp locations or exposed, unpainted applications such as shower rooms and return chases, respectively.

3.3.2 Modifying Equipment Operations

Use of equipment may need to be restricted in order to meet IAQ objectives. This could involve substituting cleaner equipment or simply changing operating procedures. Examples of such controls include:

- Restricting traffic volume or prohibiting idling of motor vehicles where emissions could be drawn into occupied areas
- Switch from diesel fuel to bottled gas for equipment such as generators or forklifts; emissions are cleaner but still potentially harmful under some circumstances (use of electric forklifts and other equipment should be considered when feasible since they do not burn fossil fuels, thus eliminating exposure to combustion gas emissions)
- Switching equipment such as saws from gasoline-powered to electric

- Adding catalytic converters to engines
- Cycling equipment off when not needed

3.3.3 Work Practice Modifications

- For some demolition tasks that have the potential to affect occupied areas (*e.g.*, paint stripping), consider techniques available which produce less airborne dust.
- Some painting techniques release fewer odors.
- Some cleaning practices raise less dust, *see* Section 3.5.
- Use of hand tools may be cleaner than power tools.
- Vacuum-assisted drywall sanders and concrete saws control dust, *see* 3.3.4.

3.3.4 Local Exhaust

Pollution sources can be directly exhausted to the outside. This may be done through an existing exhaust system, by a portable fan vented to the outside and routed to the work site by flex duct or through a vacuum attachment to a power tool. Depending on the nature of the material and the location of the exhaust, special filtration of the exhaust may or may not be necessary. Any emissions to the outside must be in compliance with applicable outdoor air regulations and should be directed well away from building fresh air-intakes, windows and occupant entry ways. Separation distances from intakes must meet applicable codes and generally should be at least 30 feet.

3.3.5 Air Cleaning

Where exhaust is not feasible, local recirculation of air through a portable air cleaner may be effective. The type of filter should be suitable for the material being controlled (*e.g.*, charcoal or potassium permanganate for many odors, a moderate to high efficiency filter for dust).

3.3.6 Cover or Seal

VOC emissions from evaporation can be reduced by sealing or covering:

- Use enclosed tanker rather than an open kettle for roofing.
- Containers of wet products should be kept closed as much as possible and always when not in use.
- Waste materials which can release dust and odors or other contaminants of concern should be labeled and covered or sealed.
- A surface which is a persistent odor source may be controlled by applying a sealer or allowing for timely off-gassing.
- Solvent-contaminated rags should be kept in closed, flame-proof containers.

3.4 Pathway Interruption

As an alternative to source controls or building evacuation, workplace air can simply be prevented from moving into occupied space. Once major pathways are identified for a given project, the following manipulations may be used to achieve environmental control:

- ***Depressurize the work area.*** This can be accomplished by adjusting the air balance using portable exhaust fans. Construction worker comfort may have to be a secondary consideration where cutting

off conditioned air to the work is needed to help establish a negative pressure environment. Some ventilation of the construction space will still be needed to dilute contaminants and as make-up air to replace exhausted air. This may be provided by air drawn into the work site from adjoining areas with portable fans.

Air exhausted to achieve negative pressure may or may not need to be filtered, depending on the nature of the materials, location of the exhaust, and any applicable regulations. Care must be taken not to exhaust air where it can be drawn back into the building. In general, at least 30 feet of separation is suggested.

As a general rule, the work site should be exhausted at a rate of at least 10% greater than the rate of supply in order to maintain an effective negative pressure. Negative pressure can be confirmed by using smoke tubes and observing the direction of air flow or through the use of a hand-held anemometer. Air flow should be in excess of 200 feet per minute across any openings if an anemometer is utilized.

- ***Pressurize occupied space.*** Increasing supply air or reducing return/exhaust air in building areas remaining occupied during construction will help exclude airborne dust and odors or other contaminants of concern. While HVAC systems, if present, generally shut down at night, consideration should be given to temporarily extending the fan schedule. Overnight pressurization could help prevent dust and odor from migrating into the space. When increasing the amount of air supplied to the occupied space, it is imperative that the HVAC system itself remains protected from construction emissions. Any temporary rebalancing during construction should be carefully planned and executed. When increasing the amount of air supplied to the occupied space, it is imperative that the HVAC system itself remains protected from construction emissions.

- ***Erect barriers to contain construction area.*** For non-asbestos projects, the extent of the barrier should be based on the materials involved and the implications of dust and odors or other contaminants of concern escaping from the site. In general, full containment of a work site with barriers, capping of return air ducts, and the application of negative pressure may be needed for spaces undergoing significant renovation, but usually not for minor remodeling, *see* additional documentation in Section 2.

- ***Relocate pollutant sources.*** When project equipment or staging areas coincide with critical airflow pathways, IAQ problems can result. In some cases, equipment can simply be moved to a more favorable location in regard to air quality. Also, air intakes can temporarily be redirected with duct extensions. Mechanical equipment might be refurbished outside or in a shop in order to relocate emissions from the building. Special care must be taken to protect mechanical rooms with air handling equipment (*e.g.,* store construction products and waste materials elsewhere).

- ***Temporarily seal the building.*** Where construction emissions are occurring on the roof or adjacent to a building, contaminants may be drawn in through entries or cracks in the outside air intake if the building is under negative pressure. If potential contaminants levels are unacceptable and source control, temporary intake relocation, or rescheduling is not feasible, then use sealing of intake dampers, windows, doors, or other pathways as a last resort. This adjustment may not be feasible where reduction in pressurization or outside air could create harmful conditions near hazardous materials. Increased infiltration of unconditioned air through building openings could also present problems.

  If this option is considered, it is important to verify acceptance by code and fire personnel as it will likely violate egress or fire codes.

3.5 Housekeeping

Dust accumulation at a construction site will become airborne when disturbed. Similarly, spills or excess applications of products containing solvents may increase odors at a construction site. And, leaving the work site wet for more than 48 hours could result in mold growth. Attention to site cleaning and maintaining dry work areas is, therefore, important to maintaining IAQ during construction. These specific actions may be applicable in regard to controlling contaminants at the work site:

- Reduce generation of dust.
- Increase the cleaning frequency for dust based on visible inspection.
- Switch to more efficient dust collection method, such as a damp rag, wet mop, or vacuum equipped with a high efficiency particulate filter, wet scrubber or exterior exhaust, to discharge material back onto the air compared to conventional vacuuming, sweeping, or dusting. Dry sweeping should not be used in owner-occupied areas.
- Ensure that all surfaces including higher ledges, behind furniture, and inside mechanical equipment are kept clean. This can be facilitated before the start of renovation by either moving contents out of the work area or covering them.
- Remove spills or excess applications of solvent-containing products within 1-hour. Care should be taken as to selection of spot removers and cleaning agents near occupied areas. In general, products should be low odor emitters or used after hours with sufficient ventilation.
- Vacuum with HEPA filtered vacuum cleaners to prevent reintroduction of settled dust.

NOTE: See Section 8 for further discussion of moisture issues.

Cleaning requirements may require more stringent methods when hazardous materials are involved.

3.6 Scheduling

An additional control option is to ensure that construction activity and building occupancy do not overlap in time. For many projects, the immediate work area is vacated to prevent safety hazards and work disruption. Although re-occupancy may occur anytime after substantial completion of the work, IAQ concerns suggest waiting until detectable dust and odors or other contaminants of concern are eliminated. A 48 – 72-hour period of continuous ventilation after final installation and cleaning should result in an acceptable environment for re-occupancy. Where possible, the renovation site should be maintained under negative pressure during this period to prevent odor migration into adjacent areas.

NOTE: In mid-summer or –winter, the permanent HVAC system is not designed to condition hot humid or frigid air to a comfortable temperature. Longer flush-outs at less than 100 percent outside air or temporary HVAC equipment may be required.

It may also be necessary to conduct activities with a high pollution potential during off hours. *For example,* if roofing emissions cannot be excluded from the building, the work might have to be performed on an evening or weekend shift. Similarly, any work which disrupts the HVAC system or introduces odor into the system should be done during unoccupied hours, when possible. Where off-gassing odors are a major concern, work may have to be completed at the beginning of a weekend in order to allow new products time to air out sufficiently. Where occupants cannot be relocated, starting time may need to be delayed until late morning in order to accommodate clean-up of late night construction work. Some occupants, such as children, immune system impaired individuals, and individuals with other documented medical conditions,

may be particularly vulnerable to construction contaminants. Special considerations for scheduling and occupant relocation may be required. At-risk individuals should be identified during the planning stages.

3.7 Occupant Relocation

The above measures assume that construction containment is effective, occupants are being moved, or construction work is being rescheduled in order to avoid potentially harmful exposure to the building's general population. When a construction project is adequately controlled and one or two hypersensitive individuals remain concerned about IAQ, moving those individuals for the duration of the project is often the most economical and effective solution.

For some projects, creating an unoccupied buffer zone around the work area may also be needed to ensure that no odor or dust is detectable in the occupied space. The size of such a buffer zone will depend on the potential air quality problems presented by the project, the availability of temporary space, and the design of HVAC zoning. When necessary control measures are disruptive to conducting normal building activity, it may be advantageous to consider building-wide adjustments.

If relocating occupants becomes necessary, attention should be paid to environmental conditions in temporary facilities.

4.0 Heating Ventilation & Air Conditioning (HVAC)

4.1 Overview

Problems may occur when existing HVAC systems also serve construction work areas, differential pressure relationships cause dust and odors or other contaminants of concern to migrate into occupied areas, or HVAC equipment is damaged or contaminated during construction. Return ducts or plenums routed through construction zones may transport construction-generated dust and odors or other contaminants of concern to occupied areas. New ducts and HVAC equipment installed during construction may also become contaminated by sources of dust and odors or other contaminants of concern, if not protected.

Early startup of HVAC systems, for example to "bake out" odors or to accelerate concrete drying, can reduce equipment life and operating efficiency where the use of the permanent HVAC system is available in construction areas. Early startup should be avoided. In addition, frequent inspection and maintenance of operating systems during the construction period is needed to address the potential degradation from dust, moisture and mold growth, all of which may impact air quality.

When installing HVAC systems, sealants, adhesives, cleaners, paints, solvents, lubricants and other products are used, which may impact air quality. Source control or product substitution should be considered where dust or odors or other contaminants of concern present potential problems, *see* Section 3. Installation equipment, such as the use of torches, welding, and soldering, often require local exhaust, favorable pressurization, or off-hours scheduling to prevent occupant exposures.

4.2 HVAC Protection

All HVAC equipment must be protected from collecting not only dust, but also odors or other contaminants of concern which can "stick" to porous materials in the system, for subsequent release back into the air. Each system must be evaluated in detail to determine how it may be affected by dust and odors or other contaminants of concern from the project (including site egress, staging areas, etc.)

Options for protecting HVAC equipment include using temporary heating or cooling (often the most effective), sealing openings, disconnecting ducts, filtration, installing temporary ducts, and controlling pressurization. A review of HVAC systems should be performed before the start of each renovation phase, at a minimum, identifying which systems are within the work area and which of those also serve occupied areas. Specific HVAC protection requirements generally apply to the return side, central filtration, or supply side of the system.

4.2.1 Return Side

The return side of an HVAC system is under negative pressure and thus capable of drawing in nearby construction dust and odors or other contaminants of concern and distributing them throughout the building. Special attention must, therefore, be paid to the location of any return vents, return ducts, ceiling plenums, return shafts, VAV plenum intakes, window units, and transfer vents as well as that portion of the air handler which is upstream of the central fan. Containment considerations include:

- When possible, the entire system will be shut down during heavy construction or demolition.
- The system will be isolated from the surrounding environment as much as possible, all tiles should be in place for a ceiling plenum return, and air handler leaks repaired to prevent induction of pollutants.
- All return system openings, in or immediately adjacent to, the construction area should be sealed with 6-mil plastic.
- When the system must remain operational during construction, temporary filters can be added on return air grilles. Suggested minimum efficiency for such filters is 30 percent atmospheric dust spot or a MERV Rating of 6 or higher where feasible. All filters must receive frequent maintenance and be replaced at the end of the project with specified filters.
- Where the permanent HVAC system remains operational, the heaviest work areas will be otherwise blocked if temporary imbalance of the return air system does not create a problem.
- Mechanical rooms with return-side equipment will not be used to store construction or waste materials and must be isolated if work is performed in this room.

4.2.2 Plenum Protection

Spaces serving as air plenums are important pathways for dust and odors or other contaminants of concern. Therefore, protection of air plenums must be evaluated. Options include the following:

- Disconnect ducts in the construction zone from the remainder of the active system and seal openings.
- Replace missing ceiling tiles, especially where the ceiling plenum is the return air path.
- Seal openings in new ducts until the construction is finished.
- Consider converting a return air plenum to a ducted system when renovation is scheduled for that area.

Areas with raised access floors (RAF), with or without under floor air distribution (UFAD) systems, present significant challenges for maintaining IAQ during construction. While modifications to demountable partitions and furniture, electrical systems, communications systems, and computer equipment might not generate much dust and odors or other contaminants of concern; removal or modifications of floor panels could depressurize the plenum, causing comfort problems in other areas. If dust and odors or other contaminants of concern producing operations are conducted, including in adjacent non-RAF areas (restrooms, lobbies, kitchens, laboratories, etc.) RAF and UFAD plenums could easily transport construction

generated contaminants or become contaminated themselves. Once contaminated, cleanup of RAF/UFAD plenums could be difficult. Establishing barriers might be difficult because of ducts, piping, cables, and conduit usually located beneath the RAF. Therefore, construction in buildings with RAF/UFAD systems should be carefully planned. Factors for consideration should include the following:

- Consider types of construction and contaminants generated.
- Consider establishing containment barriers at naturally occurring barriers such as smoke barriers. Check that barriers are sealed.
- Determine if the work area HVAC system can be isolated from other areas.
- Prepare for a sprinkler damage event including having equipment readily available for quick water removal, cleanup and drying.
- Plan how RAF/UFAD will be cleaned if they become contaminated.
- For dust or odorous work, consider scheduling during unoccupied periods with permanent HVAC systems off and sealed as a general construction policy.

4.2.3 Supply Side

HVAC systems in an area where major demolition is scheduled should be de-energized. Equipment left in place should be wrapped (*e.g.,* in 6-mil plastic sheeting). Ducts serving both the occupied and construction areas shall be isolated by sealing openings, closing dampers, or disconnecting the ducts. Direct expansion HVAC systems should be evaluated as to whether reduced airflow will adversely affect direct expansion coil operation. New HVAC equipment should be protected from the weather, dust and physical damage with appropriate planning and site management. For example, storage of ducts should be located away from masonry or tile cutters, drywall sanding, mortar or plaster mixing, roof pitch kettles, electric generators, and walkways that are frequently broom swept. Duct sections should also be stored in clean, protected areas and shielded from rain to protect against moisture.

Diffusers, VAV boxes, and ducts must be adequately protected in case where the above measures are implemented. When the system is off for the duration of construction, diffusers and window units should also be sealed in plastic for further protection. Ducts, diffusers, and window units should be inspected for cleanliness upon completion of the work and vacuumed or wiped where needed. If significant dust deposits remain in the system after construction, some particulate discharge can be expected during start-up. When such a discharge is only minor, delaying re-occupancy long enough to clean up the dust may be sufficient. In more severe cases, installing temporary coarse filters on diffusers or cleaning the ducts may be necessary. The condition of the main filters should be checked whenever visible particulates are discharged from the system.

4.2.4 Central Filtration

Where major dust loading is expected to impact operating HVAC systems, consideration should be given to upgrading filter efficiency. For example, filters with 60 to 80 percent dust spot efficiency (MERV 11-12) may provide increased protection, if minimum airflow can be maintained. Where source control options for construction-related odors are deemed effective, consideration should be given to filtration with media such as activated charcoal or potassium permanganate.

4.3 HVAC Scheduling

Problems often occur when HVAC systems are started before HVAC controls are operational or construction is complete. HVAC systems are designed to condition clean buildings protected by vapor barriers not the dust, moisture, and odor loads associated with the construction process. Use of new HVAC systems in this manner is generally prohibited without authorization and may negatively affect equipment warranties and increase the potential for poor IAQ once building areas are occupied. Provisions for temporary systems should be evaluated.

HVAC scheduling may involve planned or unplanned shutdowns of HVAC systems in occupied areas due to renovation activity. Contingency planning should include ways to minimize such problems, which may be highly disruptive.

Just prior to first occupancy, as per contractual procedures, verify that HVAC systems are clean and operating as designed. To minimize off gassing and odors from new building materials, fan schedules should be temporarily adjusted to provide continuous ventilation, including increased outside air, before and after initial occupancy.

4.4 HVAC Cleaning

The HVAC system and components should be cleaned during renovations when either an old system with pre-existing dust build-up must be rehabilitated or a "clean" system is not fully protected during the construction process. In cases, a decision to undertake duct cleaning and how to perform duct cleaning should be based on a detailed visual inspection of the system. The sequence in which duct cleaning occurs in the overall construction process needs to be carefully considered to avoid recontamination. At this time, delaminating insulation should also be repaired and any blocked condensate drains should be clean out.

4.5 Pressurization

In addition to source control and scheduling, establishing pressure differences between construction work areas and occupied areas provides another option for controlling migration of construction contaminants to occupied areas, *see* Section 3.4. Desired pressure differentials may be achieved by balance adjustments. For example, exhaust or return flow could be reduced or eliminated or supply flows can be modified (*e.g.*, increase one room, decrease adjacent room). The following factors may also temporarily change building pressurization and should be considered when selecting pressurization control strategies:

- Building stack effect
- Wind effects
- HVAC economizer controls
- Start-stop of exhaust fans
- Elevator piston effect

Changes in building infiltration should also be examined to understand whether potential moisture transfer driven by unusually high pressurization differences through the building envelope may be an issue.

5.0 Pre-Renovation Building Evaluation

5.1 Objectives

Effective management of IAQ during the construction project requires additional information relating to building history, occupant concerns, potential sources and pathways, and operations and maintenance.

5.2 Procedures

5.2.1 Historical Review

Prior to beginning each task, an historical review should be conducted to document past IAQ concerns or potential IAQ factors for the specific task area. Interviews with facility management, O & M personnel, and representative occupants may help clarify the timing, location, and nature of past IAQ concerns (both technical and perceived) and whether they were resolved.

5.2.2 HVAC Systems

To the extent HVAC systems exist, a review of performance and potential construction containment changes shall be evaluated prior to each task. The evaluation should include consideration of the following:

- Will ongoing or intermittent ventilation or conform deficiencies impact the project area?
- What balance or control adjustments can help preclude emissions from migrating to occupied space?
- Are there pre-existing contaminants in the building?
- Should mechanical equipment be cleaned as part of the renovation?
- Are there leaks or drainage problems affecting HVAC equipment?

5.2.3 Source Pathways

As a baseline, all project areas should be inspected for potential sources and containment indicators as part of the pre-task planning process and before actual commencement of task-related activities. These may involve occupant equipment and activities, and exterior sources or intermittent emissions. Potential air pathways can be tracked by smoke tubes noting where they may be modified by changes in supply, exhaust, or return or by opening and closing doors and windows and sealing penetrations. Based on this information, the following questions should be answered:

- What impact is expected on a worst-case basis?
- What building areas might be affected?
- When are worst-case conditions expected?
- Are there pre-existing IAQ problems that might later be attributed to construction?

5.3 Data Evaluation

Based on pre-task survey findings, it may be beneficial to restore deficient HVAC operations and resolve other IAQ concerns before starting the task process. If this is not practical, construction containment controls should be implemented and verified prior to commencing task-related construction activities.

6.0 Containment

6.1 Overview

Construction barriers for indoor air quality are used to prevent the migration of dust and odors or other contaminants of concern into occupied areas. They may also facilitate cleanup of the work area by minimizing the spread of contaminants. IAQ barriers include, for example, simple dust curtains and drop cloths where only minor dust is involved, to a continuous seal around the worksite with controlled ventilation. The extent of the barrier is based on the implications of dust and odors or other contaminants of concern escaping from the site. Where no detectable dust or odor can be tolerated beyond the site, a full containment with negative pressure, similar to techniques used for asbestos removal, may be necessary. For minor remodeling, where odor is considered a temporary nuisance and any release of dust can be addressed by housekeeping, a minimal barrier should be acceptable although consideration must be given to occupants.

Barrier effectiveness is determined by the potential for odor or dust generation. This, in turn, is a function of construction material, sealing of penetrations, sealing and ventilation.

6.2 Guidelines

IAQ containment barriers are generally not mandatory. Small projects can be contained by sealing with 6-mil plastic sheathing with overlapping flaps for access. As a general rule, when barriers are utilized, the contractor is responsible for monitoring barrier integrity, repairing any gaps, and cleaning the work area daily as may be needed.

In addition to the containment specifications listed in Sections 6.3-6.5, the following project requirements will be observed unless a deviation is authorized in writing by a city representative.

HVAC Ductwork

- The ends of ductwork will be sealed at the fabrication site and will remain sealed until installed.
- The ductwork terminations of installed systems will remain sealed until placed in use.

Construction Barriers

- All construction barriers will be of permanent construction (2x4 framing with sheetrock surfacing on occupied-side).
- The access door between construction barriers and occupied spaces will be a framed, incorporate a hinged door, and be clearly marked.
- A vestibule will be installed on the “dirty side” of the construction barrier. At a minimum, the vestibule will be constructed of 6-mil polyethylene sheathing with taped seams. The exit of the vestibule will incorporate polyethylene doors with overlapping flaps. The vestibule will include a tack-mat and be ventilated to create a negative pressure.
- Construction barriers will be sealed from floor to ceiling.

The following examples illustrate containment design under minimal (small-scale dust disturbance), moderate (some potential for dust and odors or other contaminants of concern release into occupied space) and maximum (large-scale, substantial dust and odors or other contaminants of concern or hypersensitive occupants):

6.3 Basic Containment

- Move contents, if present, from room or cover with plastic sheeting.
- Create critical barriers by sealing with adequate 6-mil plastic sheathing. This may include HVAC vents, doors, and other penetrations into the space.
- Place plastic drop cloth under work site to facilitate capture and disposal of debris (if in occupied space).
- Shut down or block off local HVAC openings.
- Wipe down all affected surfaces until visibly clean before occupancy.

6.4 Intermediate Containment

- Move contents from room, if present.
- Construct adequate 6-mil plastic containment around work area with overlapping flaps for entry.
- Seal interior surfaces including cabinets, carpets, etc., if present.
- Shut down and block off HVAC openings.
- Operate HEPA air scrubber in each work area.
- Clean affected areas with HEPA vacuum to remove all visible dust followed by wet-wiping if required.

6.5 Advanced Containment

- All work areas will be sealed from all occupied space by solid barriers extending floor to permanent ceiling including concealed passages such as built-end air shafts or under floor plenums.
- Construction shall be wood-framed with sealed joints and sheetrock on the occupied-side, but may include plastic sheathing with written permission depending on site-specific conditions and occupancy. All access doors to occupied spaces shall be through doors with intermediate vestibule inside the work area.
- All penetrations from the work area shall be identified and sealed.
- Emergency exit doors shall be installed as required, and be self-closing with weather stripping.
- The containment shall be operated under negative pressure, with makeup air provided to allow for adequate air distribution. Verification of negative pressure will be accomplished with smoke tubes or evaluated for air flow with a hand-held anemometer, confirming a flow of at least 200 feet per minute.
- A vestibule shall be included to change clothes, clean tools, etc., if needed.
- Periodic inspections with smoke tubes or the hand-held anemometer shall be scheduled to check barrier integrity and confirm negative pressure a minimum of once per week or anytime a complaint is logged.
- Containment will be maintained until demolition is complete and cleaning is at a level deemed acceptable as per project specifications.

7.0 Construction-Specific Moisture Control

7.1 Mold Basics

Mold is naturally present in all indoor and outdoor environments. Where excessive moisture or high relative humidity is present for a sufficient period of time, mold will grow on surfaces, and spores (“seeds”) will

discharge into the air. Drying will eventually stop mold growth, although previous growth can still become airborne if disturbed.

Mold growth in buildings can have structural, aesthetic, or health implications. Sustained wet conditions can create wood rot. Active mold growth generates musty odors and unsightly surface staining. While the majority of occupants generally do not react to minor building mold growth, hypersensitive individuals may exhibit allergies, and immune-compromised individuals may be subject to infection. All claims of allergic reactions should be evaluated/confirmed by a medical professional. Although mold growth is not regulated in most jurisdictions, preventative or remedial measures are appropriate best management practices for construction projects.

7.2 Construction-Related Moisture Problems

Since the underlying cause of all mold growth problems is moisture, understanding the sources and controls of moisture associated with building construction is essential. Conditions which may lead to air quality problems (musty odor, spore release) during construction include the following:

- Demolition of materials subject to previous mold growth
- Use of building materials with visible mold growth. *Note: Some discoloration is normally present on many wood products. Inadequate protection during stockpiling could promote additional growth.*
- Normally moist materials, such as concrete, which emit moisture for an extended period of time after installation
- Exposure of interior materials before the roof, windows, etc., are fully enclosed
- The presence of uncontrolled hot, humid air prior to activation of air conditioning, leading to condensation on cooler surfaces
- Defective moisture barriers in the building envelope (flashing, membranes, tec.)
- Ongoing roof, window, or façade leaks
- Drainage problems around the building
- Releases from plumbing and sprinkler systems
- Application of wet products (*e.g.*, humidification, temporary air-conditioning/dehumidification)
- Blocked condensate drains in air-handling units
- Under-floor air distribution systems subject to moisture problems from leaks or condensation near a poorly insulated exterior wall

In general, materials which remain damp may promote mold growth.

7.3 Prevention

Focus should be on controlling/minimizing moisture in the construction area. Measures which may be applicable include:

- Isolating demolition areas with pre-existing mold growth, followed by detailed cleanup and sanitizing
- Protecting stockpiled materials from excessive moisture (resistance of material depends on factors such as porosity)
- Minimizing period that structure is open to the elements and removing any standing water in the interim
- Completing drainage construction early to divert water from the structure
- Substituting moisture-resistant products for conventional core wall, etc.

- Conducting quality control inspections to ensure flashings and other barriers are effective
- Dehumidifying where damp conditions develop
- Allowing high moisture content materials to sufficiently dry before covering or enclosing
- Regularly inspecting all areas under construction (including HVAC equipment) for signs of excessive moisture or suspect mold growth. Mold growth locations can be recognized visually, in most cases, as a raised, powdery deposit where moisture has been present, discounting stains likely created by construction or occupant activity.

7.4 Mold Cleanup

Where damp conditions persist for more than 48-hours, mold growth may occur. It is recommended that this be prevented as soon as possible (eliminate the source of moisture and dry the affected area within 24-48 hours) while minimizing exposure to the mold (*e.g.*, replace, clean, or treat moldy material).

A fundamental step in mold remediation involves tracking moisture and water damage to locate both the water source and the areas subject to mold growth. In addition to an informed inspection (based on history and structural knowledge), moisture meters can be used to identify areas with high relative moisture content. Depending on the water pathway, it may be helpful to cut access holes into wall or ceiling cavities and determine whether indicators of excessive moisture or suspect mold growth are present. Precautions are generally taken during such access to avoid exposing occupants and to ensure a clean area when the procedure is completed.

As soon as the impact area is located, steps must be initiated to promote effective drying. This may involve a combination of removing standing water, operating dehumidifiers, and circulating air with portable fans. Care should be taken to avoid spreading spores into occupied spaces.

After drying and elimination of the water source, the work area must be configured with an appropriate level of containment (*see* Section 6), and moldy materials must be removed, cleaned, or treated, depending on their condition. Surface growth on wood which is still intact structurally may only be treated (*e.g.*, HEPA vacuumed) and sanitized with permission. Carpets in the potentially affected area without visible mold growth can be sanitized. However, in no case will damaged, water logged, or moldy materials be allowed to remain or be reinstalled.

Extensive mold remediation associated with or caused by construction activities, shall involve a clearance process (independent party determines if the area is acceptable for re-occupancy). The name of the qualified independent party shall be provided to the Facilities Manager prior to commencing any mold cleanup.

While cleanup of localized mold growth may be accomplished by general construction or maintenance personnel, a specialized restoration contractor may be needed to effectively resolve more widespread situations. The decision to use a remediation contractor will be discussed with the Facility Manager as part of the remediation planning process.

8.0 Quality Control

8.1 Adopted Standards

Primary standards governing building renovation projects are set by the Occupational Safety and Health Administration (Federal OSHA or its State counterparts). These include air quality and safety protection for site workers but do little to address impacts on building occupants' IAQ. OSHA air quality standards apply

to personal exposure at the immediate worksite only and are set to protect healthy working adults only. Compliance methods may include respiratory protection and local engineering controls. Other OSHA regulations cover confined spaces, fall protection, electrical safety, etc. In some cases, methods adopted for OSHA compliance may aggravate IAQ concerns. For example, local ventilation controls could move pollutants into adjacent, occupied areas. Such control strategies may have to be modified to meet both worker and occupant protection objectives.

The presence of construction dust and odors in occupied areas is often considered unacceptable and may give rise to nuisance and health complaints, even when the levels of exposure are minimal. For this reason, construction-related air contaminants should be prevented from entering occupied areas. This guide utilizes the best practices and recommendations of the Sheet Metal and Air Conditioning Contractors' National Association publication, *IAQ Guidelines for Occupied Buildings Under Construction, 2nd Edition,* to accomplish this objective.

However, it is generally not feasible to set specific IAQ criteria for a construction project because exposure cannot be easily measured when pollutants are present in complex mixtures with each specific contaminant at a parts per billion concentration and no one pollutant dominating from health viewpoint.

General conditions rather than specific pollutant levels provide a more realistic basis for deciding if IAQ is acceptable. Goals for acceptable IAQ are expressed in terms of ventilation, comfort, sanitation, and control of potentially significant sources of emissions. Building air quality performance goals that are not based on contaminant concentration include:

- Demonstrate ventilation to be consistent with existing equipment and design.
- Achieve comfort levels acceptable to most occupants.
- Maintain both mechanical equipment and building surfaces in reasonably sanitary condition.
- Isolate significant emission sources from occupied space.
- Control major sources of contamination promptly.
- Conduct operations, maintenance, and construction activity to minimize occupant exposures.

8.2 Project Surveillance

Monitoring of construction projects through air sampling is generally not effective. In the majority of cases, it is simply not practical to develop a sampling strategy which will measure the right pollutant at the right time. To document how a construction project relates to IAQ, the most realistic approach is generally to directly observe the effectiveness of work practices and the status of "IAQ indicators". IAQ indicators are changes in building conditions which are detectable by the sense of smell or sight. IAQ indicators for city-wide projects include:

- An unusual odor in the occupied space (not normally present)
- Visible haze in the air
- Visible accumulation of dust on exposed surfaces in occupied areas
- Staining on surfaces (*e.g.,* from soot or mold growth)
- Visible moisture or standing water
- Incorrect pressurization allowing pollutants to move into occupied areas (determined by observing direction of air movement with smoke tube, pressure gage, tissue paper, hand-held anemometer, etc.)

In addition to documenting IAQ indicators, work practice intended to protect IAQ will be reviewed to determine if they are effectively implemented. Such observations will include:

- Occupants have been removed from critical area.
- Low-emitting products have been used when appropriate.
- Frequent housekeeping has prevented dust accumulation at the site.
- HVAC protection measures have been followed.
- Dust barriers have been properly erected.
- Portable exhaust fans are being used.
- Pressurization is correct.
- Water leaks, spills, and other sources of moisture have been controlled.
- Precautions on product labels or MSDS are being followed. *Note that "use adequate ventilation" addresses air circulation to maintain safety for workers in the immediate area but may not address other occupant IAQ concerns such as nuisance odor and hypersensitivity.*
- Porous materials are protected from moisture or promptly dried.

Building occupant observations and complaints will also be considered in determining if selected controls are effective. Complaints will be addressed immediately with a thorough inspection to help identify source and pathway, *see* Section 5.2.3. If the complaint is valid, additional control measures will be evaluated. Because dust and odor problems are often intermittent, site evaluation should include occupant interviews to document the time, location, and conditions of a potential incident.

Air sampling may play a role in monitoring effectiveness, but this is generally not required. In such cases where monitoring is recommended, the sampling strategy must reflect the full range of conditions (both critical peaks and typical averages). Nonspecific indicators such as particle counts and total VOCs may be quite variable and have non-construction sources. Wherever air sampling is conducted, it is important to also document work practices and IAQ indicators to help place the results in perspective. A sampling strategy must be provided to and approved by the city prior to implementation.

A project checklist should be used during inspections to document site conditions and the status of IAQ controls. A checklist can be found in Appendix B.

8.3 Enforcement

Enforcement of work practices and maintaining air quality criteria begins with the education of construction personnel. Supervisors must be presented with the project's IAQ goals and the means for achieving them before work starts on each task. Inspection must stress consistency and fairness in enforcing work practices. In some cases, work might not be allowed to continue until IAQ concerns are successfully resolved (*e.g.*, clean up of affected space). The contractor and assigned city personnel will review documentation and site activities for compliance.

8.4 Occupancy Criteria

As previously stated, except for situations not involving lead or asbestos, clearance sampling for specific pollutants associated with general demolition or construction may not be conclusive. Criteria based on general IAQ indicators will generally provide a better basis for verifying that conditions are consistent with normal background conditions in occupied areas. These general observations will be used to determine if the area can be reoccupied:

- **Dust:** The work site should be cleaned until there is no visible haze in the air and no settled dust on surfaces.

- **Odor:** Ideally, there should be no detectable odor upon re-occupancy. This can often be accomplished by ventilating the site (continuously, if possible) for a period of time (*e.g.,* several days) after final cleaning. In situations where IAQ is not an absolute priority, odor of low intensity might be tolerated at re-occupancy if continued observation shows that it is eliminated within several weeks.

- **HVAC**: Systems should be restored to good operating condition prior to re-occupancy. This will involve rebalancing the system to ensure that it meets current occupancy needs. All ventilation and air distribution systems should be reasonably clean of dirt and debris (based on detailed visual inspection). Control systems should be functional and operating in accordance with the specified sequence of operation. Outside air ventilation should be initiated before occupancy to confirm acceptable conditions with regard to the control of odors, dust, ventilation, and thermal comfort. Specific construction documents may also specify occupancy and clearance criteria (*i.e.,* contract documents and specifications).

8.5 Documentation

All observations and communications regarding site IAQ should be documented and retained. This should include initial project specifications, change orders, status reports, inspections, and complaints with follow-up information. The contractor will maintain a Daily Job Report to document daily site activities, personnel, work locations, and complaints.

9.0 Communications Plan

9.1 Occupant Awareness

Building renovation can be a disruptive for occupants, especially during occupied-renovation projects. Fear of environmental exposures may become a major factor, especially when unexplained emissions of dust and odors or other contaminants of concern occur in occupied spaces. This may lead to complaints based on fear or rumors. It is important for occupants to know there is a plan to protect their health.

Occupants whose history suggests they may have adverse reactions (*e.g.,* be allergic to dust, chemicals) should be accommodated where possible (*e.g.,* moved away from active areas). As demolition and construction progress, occupants will be updated (specify frequency) and encouraged to voice any concerns.

Periodic progress meetings (as specified in contract documents) will be held with contractor to review all complaints and resolutions. Occupants are entitled to product MSDS. Occupants are encouraged to report problems or concerns before they become serious issues.

9.2 Complaint Procedure

The complaint procedure is designed to address two distinct populations – staff, generally consisting of employees of the city or school; and, other occupants, generally consisting of visitors, students, workers.

Staff Building-Related Complaint Reporting:

Staff is encouraged to report environmental issues such as temperature, humidity, dust, odors, moisture intrusion, etc., through the "School Dude" work order system. Entries are immediately entered into the work order system and prioritized. All complaints associated with indoor air quality should include the heading "IAQ".

Staff should report health-related complaints to their immediate supervisor or building manager as established for the particular building. Health-related complaints will be scheduled through WorkWell for evaluation.

Visitor Building-Related Complaints:

All building-related complaints should be reported to the building official immediately in order to document the date, time, and nature of the complaint. "Building official" means the highest ranking official with direct oversight of the building, i.e., principal (school buildings), department head (municipal buildings), city manager (City Hall), etc.

Student Building-Related Complaints:

Student building-related complaints (health or environmental) should be reported to the teacher in the classroom where the complaint originated and may subsequently be directed to the school nurse for further evaluation.

Worker Building-Related Complaints:

All worker building-related complaints should be reported to the project manager for the site work, or in the absence of a project manager, to the school or city point of contact for the project. The complaint information will then be investigated and transmitted to the city manager or superintendent, as applicable for further investigation.

9.3 Complaint Response

Despite careful planning and oversight, environmental incidents are sometimes unavoidable. Prompt response (within 24-hours) and clear communication with occupants is essential at such times. Where sources, pathways, and risks are not obvious, a troubleshooting investigation will be initiated. Explanations of health risks can be made by an occupational physician or industrial hygienist where there is a high level of concern. In worst-case scenarios, renovation work may need to be stopped until potentially significant health issues are resolved. Whether or not exposure can be attributed to construction activities, construction delays and evaluation costs may result from occupant-reported IAQ concerns.

Appendix A
IAQ Construction Containment Planning Checklist

IAQ Construction Containment Planning Checklist

Project _____

Phase/Area _____

Construction Activity	Potential Sources (materials, products, equipment)	Degree of Hazard minimum = Class 1 medium = Class 2 major = Class 3	Affected Areas	Occupancy	Selected Controls

IAQ Planning Checklist
Evaluation of Potential Control Measures

Control Measure	Pros	Cons
1. Barriers		
2. HVAC Protection		
3. Pathway Interruption		
4. Buffer Zone/Relocation		
5. Negative Pressure		
6. Emission Reduction		
7. Product Substitution		
8. Equipment Modification		
9. Work Practice Modifications		
10. Local/Exhaust/Vacuum Attachment to Tools		

IAQ construction Containment Planning Checklist
Evaluation of Potential Control Measures

Control Measure	Pros	Cons
11. Dust Suppression		
12. Air Cleaning		
13. Covering/Sealing		
14. Source Relocation		
15. Special Cleaning		
16. Scheduling of Hours		
17. Prevent Disruption of Building Systems		
18. Control Excess Moisture		

Comments: _____

Appendix B
IAQ Construction Containment Inspection Checklist

IAQ Construction Containment Inspection Checklist

Project _____

Status _____

Date _____ Inspector _____

	Odor	Dust	Wet	Daily Cleaning	HVAC Protection	Pressurization
Work Areas						
Occupied Areas						

Status of Control Measures		Location	Procedure	Effectiveness
			Local Exhaust	
			Pressurization	
			Barriers and Seals	
			Containers covered	
			Other	

Occupant Concerns
Comments