Chapter 13 – Indoor Environmental Quality

Introduction

1. General

a. The indoor environment is the result of the interactions of many factors - the building's location, area climate, construction methods and materials, renovations, occupant activities and furnishings, to name a few. With the focus on energy conservation in the 1970s came the idea that "tighter is better." Buildings were constructed to prevent air infiltration, but there was usually no compensation for the loss of natural ventilation. Employees in office spaces began to complain of symptoms that they associated with being at work, beginning the era of evaluating occupational health issues associated with non-industrial work environments. Over the years, indoor environmental quality (IEQ) concerns have increasingly focused on biological contamination, especially molds and their metabolic by-products.

b. This chapter is not meant to be an exhaustive or exclusive IEQ reference. It is a consolidation of current information, guidelines and references, and provides general procedures to assist you with evaluations. Further, it provides the resources to obtain more in-depth information if needed.

Section One – General Indoor Environmental Quality Investigations

1. General

The indoor environment is a result of the interaction between many factors - the building's location, climate, construction methods and materials, renovations, occupant activities, furnishings - to name a few. With the focus on energy conservation in the 1970s came the idea that "tighter is better." Buildings were constructed to prevent infiltration and exfiltration, but compensation was not always made for the loss of natural ventilation. Consequently, the number of employee complaints of sickness in the workplace began to rise and indoor environmental quality (IEQ) became an occupational health issue. This chapter is not an exhaustive IEQ reference. It is meant to provide general information and a list of references that should be read for a more thorough understanding of IEQ, sick building syndrome (SBS) and building related illness (BRI).

2. Definitions

a. Biological Contaminants. Agents that are living or derived from living organisms, such as fungi, bacteria, viruses and animal antigens. Such biologicals can be inhaled and may

cause respiratory irritation and conditions, allergic reactions, hypersensitivity and may exacerbate asthma. In rare instances, such agents may have caused infectious diseases. Also called microbials, bioaerosols or microbiologicals.

b. Building Related Illness (BRI). Illnesses for which there is a clinically defined etiology and for which there may be confirming laboratory and physical evidence. Examples include legionellosis, psittacosis and hypersensitivity pneumonitis.

c. Environmental Tobacco Smoke (ETS). The combination of side stream smoke from a lit tobacco or other smoking product and exhaled mainstream smoke and the emissions from electronic smoking devices. Also called second hand smoke.

d. HVAC. Heating, ventilating and air conditioning.

e. Indoor Environmental Quality (IEQ). The condition of the indoor environment, including such parameters as chemical and biological contaminants, physical hazards and individual perceptions or reactions to these parameters. Also called indoor air quality (IAQ).

f. Multiple Chemical Sensitivity (MCS). A condition whereby an individual experiences adverse reactions or sensitivity to multiple chemicals at extremely low concentrations. As related to IEQ, it is a controversial phenomenon without consensus about its existence, causes or resolution. Also called environmental illness.

g. Particulates. Particles, especially allergens and irritants that can be present in the air. They can usually be eliminated through good filtration methods. Particulates may serve as a core or carrier for volatile organic compounds (VOCs) or other chemicals. Also called airborne particulates and total particulates.

h. Sick Building Syndrome (SBS). A condition associated with complaints of discomfort that may include headache, nausea, dizziness, dermatitis, upper respiratory irritation, cough, fatigue, eye irritation and difficulty concentrating. Specific causes for the symptoms are usually not identified, but may be a combination of chemical, physical and biological factors and/or individual differences in sensitivity. Symptoms generally appear after spending some period of time in the work place, but lessen or disappear after leaving the work site. Also called tight building syndrome.

i. Volatile Organic Compounds (VOCs). Refers collectively to the organic vapors that contaminate indoor air. More correctly, the total VOCs (TVOCs) detected during analysis include two subgroups: VOCs (boiling point less than 0 degrees centigrade (°C) to about 260°C) and semi-volatile organic compounds (SVOCs) with boiling points from about 260°C to 400°C. VOC sources include building materials, cleaners, paints, adhesives, cosmetics, solvents and pesticides. Some VOCs typically associated with IEQ problems include benzene, xylene, toluene, methyl ethyl ketone, limonene, trichloroethylene, formaldehyde, carbon tetrachloride and other chlorinated solvents. Also called volatiles.

3. IEQ Investigation Guidelines

a. General.

(1) As detailed in Reference 13.1-1, the IEQ investigation sequence is:

(a) For buildings maintained by the Navy:

1. Individuals report problems to their supervisors.
2. Supervisors coordinate with the facilities maintenance activity and activity or region safety manager to resolve or elevate to higher authority if needed.
3. If local and regional assets are unable to determine the cause of the problem, the safety manager shall request assistance from the Naval Facilities Engineering Command (NAVFACENGCOM) for building-related issues.
4. If employees in the building are having medical issues, the safety manager will request assistance from the cognizant Bureau of Medicine and Surgery (BUMED) occupational health service.
    a. Refer employees with medical complaints to the supporting occupational health department for evaluation.
    b. Industrial hygiene (IH) will provide assistance, as needed, to help facilities resolve IEQ issues.
5. If unable to resolve the IEQ issues using the process above, the safety manager shall request further assistance through the cognizant regional NAVFACENGCOM or BUMED offices. For issues beyond the capabilities of the normal BUMED IH service provider, Navy and Marine Corps Public Health Center (NMCPHC) consultation can be requested on a case by case basis, but generally the requested IH support would performed by the cognizant BUMED industrial hygienist.

(b) In buildings where Navy personnel work but are maintained by a private enterprise, report all problems to the appropriate facilities maintenance organization. If they are unable to resolve the problems, contact the activity or region safety manager to resolve or elevate to higher authority, if needed, and continue the same sequence, described above, as for buildings maintained by the Navy.

(2) Facilities maintenance should respond to building issues. Occupational health (OH) should respond to employee complaints of occupational illness.

(3) IEQ evaluations require sound IH knowledge and practice. There is no "magic formula," nor can every investigation be conducted exactly the same way. The industrial hygienist will have to construct an evaluation plan based on employee complaints, visual inspection and professional experience. Most evaluations will involve SBS. BRI cases are less common.

(4) There is no clear definition for "good" IEQ. Reference 13.1-2 defines an acceptable thermal environment as one that a majority of the occupants would find acceptable, based on healthy adults spending fifteen minutes or more in the space. It also identifies six primary factors that affect comfort: metabolic rate (affected by the activity being performed), clothing insulation, air temperature, radiant temperature,

air speed and humidity. Reference 13.1-3 defines acceptable IAQ as "air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction".

(5) In general, to inhibit any potential mold growth, relative humidity (RH) levels should be maintained below 60%. Additionally, relative humidity should be kept low enough to prevent condensation on windows and other surfaces. You will see varying ranges recommended for RH (e.g., Environmental Protection Agency (EPA) 30-60% (ideally 30-50%); Centers for Disease Control (CDC) below 50%; Occupational Safety and Health Administration (OSHA) below 70% (preferably 25 - 60%). Reference 13.1-1 notes that unacceptable RH is generally recognized to be below 30% and above 60%.

(6) In most cases it is possible to determine if a problem exists in the complaint area, and to provide recommendations that will reduce or alleviate the problem. Do not dwell on identifying a specific cause for each IEQ evaluation.

(7) A three-phase investigation approach is recommended.

(a) Phase 1 - Initial Assessment. Evaluate complaints and determine if a problem exists. Rely on observation, interviews and minimum sample collection (usually screening samples such as temperature, RH, carbon dioxide and air flow assessment). Depending on the situation, sometimes, additional screening samples may be done for other chemicals such as carbon monoxide, formaldehyde, oxides of nitrogen, ozone, particulates, radon, sulfur dioxide and/or VOCs). General employee complaint forms or questionnaires and interviews may be useful. An example of such a complaint form would be the Reference 13.1-4 Indoor Air Quality Complaint Form.

(b) Phase 2 - Add Detail. This is warranted if the problem is not resolved with Phase 1, or if Phase 1 reveals that more detailed investigation is needed. Collect additional environmental samples and/or begin quantitative measurements. At this stage, consultation with other professionals for assistance may be needed for further assessment.

(c) Phase 3 - Exhaustive Study. This step, though rarely needed, will be required when a problem exists but cannot be resolved using standard techniques. This phase entails in-depth and detailed measurement of all potential causative agents, conducting employee interviews, distributing and evaluating questionnaires tailored for the particular investigation and asking employees to maintain daily logs of their symptoms. An example of such a diary form would be the Reference 13.1-4 Occupant Diary. Questionnaires should be used sparingly, if at all, because it is difficult to interpret the questionnaire results. Employee interviews are preferred.

(8) Successful investigations often involve a team approach with other professionals (e.g., occupational and preventive medicine, IH, safety, engineering, facilities, maintenance and/or risk communication staff).

b. Documentation Review. Before visiting the complaint site, request and review any existing written documentation pertaining to the IEQ problem. This could include employee complaints or memorandums, minutes of meetings held to discuss employee concerns, previous samples or surveys, pertinent medical information, building ventilation drawing and building renovation history.

c. Interviews. Conduct interviews, as appropriate, with the employer, building or facility manager, employees, OH staff, building maintenance and housekeeping personnel, facilities engineers and public works personnel.
   (1) The goals of interviewing are to gain an understanding of the perceptions of the problem, to identify actual events that may have triggered or be contributing to the SBS or BRI and to establish open communication with everyone involved.
   (2) Use discretion when conducting interviews. It may be most advantageous to interview employees individually and in private. In other circumstances, employees may be more comfortable talking with you at their desks.
   (3) Always be honest and non-judgmental. DO NOT show partiality to any group or individual's side of the story. Only the facts are relevant, and the purpose is to resolve the problem to everyone's satisfaction.
   (4) An example interview form and additional interview questions that are meant to serve as a starting point for the investigation would be the Reference 13.1-4 Occupant Interview.

d. Walk-Around Inspection. Conduct a visual evaluation. Verify information obtained during the interview process and identify processes, equipment or procedures that require further investigation. Using a checklist might be helpful. Appendix 13.1-A provides an example of information to inquire about during a walk-around inspection. This is meant as a basic template and information may need to be added or deleted depending on the individual situation.
   (1) The walk-around inspection should cover both inside and outside of the complaint office or building, including the work spaces, roof, basement, attic, false ceiling spaces, equipment rooms, smoking areas, crawl spaces, outdoors area, etc. Look for potential contamination sources and problem indicators such as:
      (a) Water damage to walls, ceilings and carpets.
      (b) Ceiling tiles or wall panels that have been removed.
      (c) Chemicals (e.g., copier additives, adhesives, solvents, cleaners, pesticides, perfumes, air fresheners).
      (d) Types and locations of office equipment.
      (e) Types and locations of other equipment that could affect the indoor environment (e.g., portable fans or heaters, ionizers, air cleaners, humidifiers, dehumidifiers).
      (f) Check for appropriateness of venting and for leaks in any combustion appliances (e.g. gas water heaters).
      (g) Presence of flickering fluorescent tubes.
      (h) Presence of possible glare or other lighting problems.
      (i) Presence of new building materials, furniture, carpets, partitions, etc.

(j) Presence of areas where cooking is done.
(k) Presence of areas producing a lot of water vapor (e.g., showers, kitchens).
(l) Presence of laboratory, industrial, maintenance, warehouse or other types of operations occurring in and around the building.
(m) Location of problem building in relation to adjacent industry, landfills, exhaust/emission sources, airport, agriculture, etc.
(n) Types and locations of any renovation work being done in or around the building.
(o) Location of building outdoor air intake vents (check for possible exhaust re-entrainment).
(p) Evidence of animals (e.g., nests, droppings).
(q) Odors, unsanitary conditions, poor housekeeping, blocked drains or vents, dry sanitary traps, etc.

(2) Check and record heating, ventilation and air conditioning (HVAC) information such as:
(a) Type of heating/cooling system.
(b) General state of repair/maintenance.
(c) Location and condition of HVAC equipment, including cooling towers, chillers, boilers, air handling units and the HVAC system in general (e.g., outdoor air louvers/screens (clean/dirty/damaged); outdoor air dampers and settings (adjusted properly/working/blocked); plenums (dirty/clean) and plenum drains (clogged/dirty/clean); fans and motors (working/broken); combustion appliances (e.g., gas furnaces, etc.) (proper venting/improper venting/leaks); cooling and heating coils (dirty/clean); condensate or drain pans or drains (clogged/dirty/clean); humidifiers (dirty/clean); types, location and condition of filters (missing/dirty/clean); types, location and condition of air cleaners (working/broken/dirty/clean); types, location and condition of ducts (dirty/clean); type of duct insulation (none/exterior/interior); condition of duct insulation (dirty/deteriorated); condition of supply and return air grills (dirty/discolored); inappropriately located (e.g., outdoor air intake located near a loading dock) or blocked outdoor air intakes, returns, supply or exhausts; inappropriately located (e.g., in a closet) or blocked thermostats or humidistats).

(3) Check actual HVAC function (e.g., outdoor air damper settings, outdoor air sensors, thermostats, humidistats, overrides or resets for computer-controlled dampers or thermostats or humidistats, economizer operation, fan speeds, filter or collector resistance, airflow) against design specifications and information obtained from maintenance and engineering personnel.

e. Sample Collection.

(1) In general, air samples should be taken only when there is evidence of an IEQ problem or when employee symptomatology is suggestive of a causative agent. Many investigations can be resolved with little or no sampling. If specific contaminants are suspected after completing the preliminary investigation, collect

air samples for the indicated contaminant(s). Otherwise, collect screening samples and use these results to decide if long-term sampling is warranted.

(a) Screening samples should include, as a minimum, temperature, RH, carbon dioxide and air flow assessment. Additionally, carbon monoxide, formaldehyde, oxides of nitrogen, ozone, particulates, radon, sulfur dioxide and/or VOCs are sometimes included in the screening phase, depending on the situation.

(b) Commonly used screening sampling methods are listed in Appendix 13.1-B. For additional information, consult References 13.1-4, 13.1-5, 13.1-6 and 13.1-7.

(2) Samples should be collected at outdoor air intakes, near return air ducts, near potential indoor and outdoor contaminant sources and in complaint and non-complaint employee work areas. At least one outdoor ambient air sample should be taken for reference. Sampling sites should be representative of complaint, control (i.e., negative) and contaminant source zones.

(3) Sampling should be done throughout the work day, such that both "worst case" and typical periods are likely to be sampled. It may be helpful to have employees keep Occupant Diary on sampling days to allow comparison of test results and complaints.

(4) Collecting biological contaminant samples, such as mold, is generally unnecessary, particularly when there is visible contamination. For information on biological contaminant sampling see Chapter 13 Section 2.

f. Ventilation System Testing.

(1) Carbon dioxide is a common measurement in IEQ evaluations. It is used as a surrogate indicator of ventilation adequacy. (As detailed in Reference 13.1-3, a higher incidence of employee complaints has been associated with carbon dioxide levels above 700 parts per million (ppm) over the outdoor air concentrations. This is primarily based on the perception of human bio-effluents [body odor].)

(2) Evaluation of the HVAC system should include:

(a) Air temperature, RH, air flow and carbon dioxide measurements.

(b) Noting times that the system is turned off.

(c) Noting the type/frequency of inspections and maintenance.

(d) Inspection of the HVAC system, including mechanical rooms, control systems, cooling towers, chillers, boilers, air handling units and the HVAC system in general (e.g., outdoor air louvers/screens, outdoor air intakes and surrounding areas, outdoor air dampers, settings and sensors, plenums and plenum drains, fans, motors, any combustion appliances, cooling and heating coils, condensate or drain pans, humidifiers, drains, filters, air cleaners, ducts, duct insulation, exhausts, returns and supply, air grills, thermostat and humidistat controls).

(e) Look for such things as poor outdoor air intake, return, supply or exhaust location, closed or blocked dampers, inoperable fans or motors, improper venting or leaks of any combustion appliances, dirty or contaminated coils, moisture problems (standing water or contamination in the condensate or drain pan, clogged drains, standing water, water damaged or contaminated plenums, air handlers or ducts), dirty or missing filters, inoperable or dirty air cleaners, dirty ducts, dirty or deteriorating insulation (particularly if the ducts are

insulated on the inside), dirty or discolored supply or return air grills, poor thermostat or humidistat location, etc.

(f) An HVAC checklist could be used for gathering this information. An example of such an HVAC checklist form is Reference 13.1-4 HVAC Checklist Short Form. Reference 13.1-4 also contains the HVAC Checklist Long Form which provides useful information.

4. Interpretation of IEQ Sampling Results

a. Do not collect samples unless prepared to interpret and explain the results. This is especially true when sampling for biological contaminants or when doing scans or "panels" for chemicals. Since there are no IEQ compliance standards, be careful what comparisons are used to interpret data. Use recommendations and guidelines with the understanding that there may be other physical factors (e.g., ergonomic design, noise, vibration, lighting, video display terminal usage) or less easily defined contributors (e.g., comfort level, stress factors, job satisfaction, psychosocial influence) involved. Although such factors can profoundly influence the IEQ evaluation, they cannot be easily addressed quantitatively.

b. Appendix 13.1-C lists some recommendations and guidelines for IEQ chemical and physical sources. Consult the cited references for further information and clarification. For information on interpreting IEQ biological source sampling results see Chapter 13 Section 2. Use extreme caution when interpreting any sampling results for IEQ physical, chemical or biological sources. Individual hypersensitivities can result in IEQ complaints even though sampling results are well below recommended levels.

c. Look for patterns in data, symptom onset and complaint fluctuations especially as related to changes in, or patterns of, processes within the building. Also, comparing and contrasting results (e.g., inside versus outside, complaint versus non-complaint, morning versus afternoon) is usually more helpful than strict comparison with recommendations.

d. Natural fibers (e.g., asbestos) and man-made fibers (e.g., fibrous glass, mineral wool, refractory ceramic) may be identified as a contaminant source during IEQ investigations. These topics are adequately addressed elsewhere (see References 13.1-8 and 13.1-9).

5. Remediation

a. Successful IEQ remediation depends on reducing or eliminating air contaminant levels (if found) and addressing health complaints. Unfortunately, IEQ problems are often the result of a combination of factors, some of which may not be easily resolved (i.e., psychosocial influences). Remediation may also be tempered by economics. Inexpensive solutions are more likely to be accepted and implemented by building owners or employers.

b. There are “general” guidelines that may be useful, but good IH practice is usually sufficient to alleviate IEQ problems. Never hesitate to consult with engineers (HVAC,

mechanical, design, etc.), maintenance personnel or others who may have expert knowledge of building design, renovation or maintenance. Solutions are usually a multi-disciplinary effort.

c. IEQ Remediation Guidelines.

(1) Ventilation.

(a) Ensuring an adequate supply of fresh outdoor air is probably the single most effective way to resolve IEQ problems (see Reference 13.1-3). This may be as simple as opening outdoor air intake louvers or dampers.

(b) Relocate/redesign outdoor air intakes that are entraining outside contaminants. If building exhausts are potential contaminant sources, it may be necessary to raise the stacks or relocate them away from all outdoor air intakes.

(c) Ensure all furnaces and combustion appliances, requiring venting, are properly vented to the outside and regularly checked for leaks to prevent carbon monoxide entering spaces.

(d) Air grills (diffusers) should be open and not blocked to ensure adequate delivery and mixing of air. It may be necessary to relocate desks, bookcases or room dividers to enhance room air mixing.

(e) Unblock or relocate any blocked or improperly located thermostat or humidistat controls.

(f) Routine HVAC preventive maintenance is a must. As a minimum, per Reference 13.1-3, it should include inspection and maintenance for such items as: filters and air cleaning devices; outdoor air dampers and actuators; humidifiers; dehumidification coils; drain pans and adjacent surfaces; outdoor air intakes; outdoor air intake louvers, bird screens, mist eliminators and adjacent areas; sensors; air handling systems; cooling towers; and plenums and plenum drains floor drains. Reference 13.1-3 also lists checking the quantity of outdoor air flow provided to air handlers, equipment and component accessibility, visible microbial contamination and water intrusion and accumulation, as part of preventive maintenance. Checking such additional items (e.g., fans, motors, belts, heat exchangers, burners, pilots, proper venting/leaks, compressors, refrigerant, ducts, return and supply air grills, safety devices, thermostat and humidistat controls) are also sometimes included in preventive maintenance plans.

NOTE: Make sure that ALL filters in filter banks are changed during maintenance.

(g) HVAC system component cleaning should be done following recommended guidelines and practices (see References 13.1-4, 13.1-10 and 13.1-11). Additional information is available from the Environmental Protection Agency. For information on remediation and cleaning for biological contaminants see Chapter 13 Section 3.

(h) Remove and discard any damaged or damp insulation in the ventilation system. Ventilation ducts should be wrapped with foil-backed insulation rather than using ducts with internal insulation.

(2) Air Treatment.

(a) Maintain temperature and humidity as recommended by Reference 13.1-2. Also, the Centers for Disease Control and Prevention (CDC) Mold Basic Facts and Environmental Protection Agency (EPA) Mold Resources pages and Reference 13.1-12, make a general recommendation of keeping the RH level above 30% (EPA) and below 60% (EPA) and ideally below 50% (CDC and EPA). Generally, RH levels <60% will inhibit mold growth. Additionally, RH should be kept low enough to prevent condensation on windows and other surfaces. Also, Reference 13.1-13 notes that studies indicate RH greater than approximately 50% increases indoor dust mite levels.

(b) If contaminants are being introduced from outside, consider additional filtration in the HVAC system. Filters may be needed for particulates, gases or both. Electronic cleaning devices provide an alternate or additional removal system.

NOTE: If not properly installed and maintained, such electronic devices may generate ozone.

Reference 13.1-3 has guidelines for filters or air cleaners, as needed for HVAC systems located in areas where outdoor air concentrations exceed certain PM10 or PM2.5 particulate or ozone levels.

(3) Source Control.

(a) Isolate any areas being renovated, painted or carpeted. Consider having isolated construction areas under slight negative pressure. Consider checking to see that the HVAC system for construction area does not entrain dusts or other contaminants from the renovation and carry them to occupied areas. If isolation is not feasible, consider having the work done when the building is not occupied.

(b) Adjust combustion sources (e.g., furnaces, water heaters) to ensure proper fuel burning. Ensure they are properly vented, regularly checked for leaks and that preventive maintenance is performed.

(c) If contributing to IEQ problems, install local exhausts as necessary to control contaminants generated by specific processes.

(d) Control tobacco use. The Navy and Marine Corps vision is to be tobacco free. Reference 13.1-14 and 13.1-15 prohibit the use of tobacco on all Navy facilities and Navy controlled spaces, except as noted in Reference 13.1-15. Reference 13.1-15 describes policy requirements for designated smoking areas, including being located away from building air intakes and points of ingress and egress, etc.

(e) Perform good housekeeping routinely.

(f) Remove chemical emission sources and/or provide non-irritating, “green” environmentally friendly substitutes for building products, furnishings, carpets, paints, cleaners, etc. Recommend using low odor cleaning products.

(g) To control excess moisture, install and use exhaust fans in areas where a lot of water vapor is produced (e.g., possibly showers, kitchens, bathrooms, etc.). Also, if possible vent any appliances that emit water vapor outside.

(h) Immediately repair any sources of leaking water (water supply pipes, condensers, drains, roof leaks). Ensure buildings have proper grading and drainage to move water away from the building. Eliminate all standing water, especially in air handling units, plenums, condensate or drain pans or ducts. Whenever possible, discard water damaged materials or furnishings (e.g., carpet, wallboard, ceiling tiles, upholstered furniture, insulation, etc.). Thoroughly clean and disinfect remaining water damaged areas. For information on remediation and cleaning for biological contaminants see Chapter 13 Section 3.

6. Follow-Up

a. Always conduct follow-up assessments. Contact by phone or site visit is recommended within 2-3 weeks following completion of the investigation.

b. If problems persist, consider the following options:
   (1) Revisit the site and determine which recommendations have been implemented. Is there any change in employee complaints, attitudes or perceptions of employer assistance? Are there any new problems since the initial evaluation?
   (2) Offer additional assistance, particularly if the building manager/employer is unsure of where or how to get started. You may be able to help prioritize recommendations, participate in planning solution strategies or provide IEQ training.
   (3) Begin Phase 2 or 3 evaluation, if needed.

c. If IEQ problems cannot be resolved locally with facilities maintenance, safety, NAVFACENGCOM or cognizant BUMED occupational health service resources, request further assistance through the cognizant regional NAVFACENGCOM or BUMED offices, as outlined in Reference 13.1-1.

7. References

13.1-1. OPNAVINST 5100.23 Series, Chapter 30, *Indoor Air Quality*.

13.1-2. ASHRAE. *Thermal Environmental Conditions for Human Occupancy*. ASHRAE 55-2017. Atlanta, GA: ASHRAE. 2017.

13.1-3. ASHRAE. *Ventilation for Acceptable Indoor Air Quality*. ASHRAE 62.1-2016. Atlanta, GA: ASHRAE. 2016.

NOTE: For low rise (3 stories or fewer above grade) buildings consult ASHRAE. *Ventilation and Acceptable Indoor Air Quality in Residential Buildings.* ANSI/ASHRAE 62.2-2016. Atlanta, GA: ASHRAE. 2016.

13.1-4. United States EPA/National Institute for Occupational Safety and Health (NIOSH). *Building Air Quality: A Guide for Building Owners and Facility Managers*. DHHS (NIOSH) Pub. No. 91-114 (EPA/400/1-91/033). Washington, DC: United States Government Printing Office. 1991. http://www.cdc.gov/niosh/docs/91-114/

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13.1-8. OPNAVINST 5100.23 Series, Chapter 17, *Asbestos*.

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13.1-12. United States EPA. *Mold Remediation in Schools and Commercial Buildings*. EPA/402/K/01/001. Washington, DC: United States Government Printing Office. 2008. http://www.epa.gov/mold/mold_remediation.html; https://www.epa.gov/mold/printable-version-mold-remediation-schools-and-commercial-buildings

13.1-13. World Health Organization (WHO) Europe. *WHO Guidelines for Indoor Air Quality: Dampness and Moulds*. Denmark: WHO Regional Office for Europe. 2009 http://www.euro.who.int/__data/assets/pdf_file/0017/43325/E92645.pdf

13.1-14. OPNAVINST 6100.2 Series, Health Promotion Program.

13.1-15. SECNAVINST 5100.13 Series, Navy and Marine Corps Tobacco Policy.

Section Two – Mold and Other Biological Contaminant Assessments: Investigating, Sampling and Interpreting Results

1. General

a. Microbes, microbiologicals, bioaerosols, biological contaminants - all terms for the broad category of airborne particles that are living or have biological origins and are generally part of our natural ambient environment. This includes fungi, bacteria, viruses, protozoans, pollen, animal dander, insect parts and feces and human skin scales. While these are all important in IEQ assessments, by far the most widely suspected, sampled and publicized members of this group are the fungi. This section will discuss primarily mold assessments but will also cover some other biological contaminants as well.

b. The number of requests for mold investigations has been steadily climbing. There are no regulations or standards for mold, so it is often difficult for occupational health professionals to interpret data. Further, most of the underlying reasons for mold contamination originate with building construction or maintenance problems, so it may be difficult for the industrial hygienist to effect the changes needed to resolve occupant complaints.

2. "Rules" for Mold and Other Biological Contaminant Assessments

The following tenets are the foundation for all biological contamination investigations:

a. Prevention is the best way to keep biological contamination from becoming an issue. The key elements of prevention are timely maintenance and prompt repair of facilities and general moisture control.

b. Reporting a mold or other such biological contamination issue follows the steps outlined in Chapter 13 Section 1.

c. Investigations are a team effort, requiring the assistance and cooperation of facilities and maintenance, safety, IH, OM, preventive medicine, occupants, labor representatives (if applicable), housing or office managers and command public affairs officers.

d. Open, honest communication is vital between the personnel conducting the investigation, occupants and management. At least one team member should be trained in risk communication.

e. As it is typically the result of excess moisture on materials indoors, if biological contamination such as mold is found or suspected, immediate action is required to identify and fix the water intrusion source, dry the area and clean or discard contaminated items. The goal is to minimize the health risk for occupants. While healthy individuals are seldom at risk from mold exposures, there is increased concern for those who are very young, old, debilitated, immunocompromised by other diseases or severely allergic to mold.

Looking for evidence of water damage and visible mold growth should be the first step. If visible mold is present, sampling is usually unnecessary and the mold should be appropriately remediated. Sampling for mold is not recommended except in certain circumstances such as verifying a medical diagnosis. Results from mold sampling and the species of mold do not change the requirement to locate and stop the water intrusion. In addition, there are no health standards for what are "acceptable" levels of mold in the indoor environment; so there is no health standard to which to compare mold sampling results. Sampling results do not change the requirement to stop the water intrusion and clean up the contamination, and may confuse the issues simply because there are no mold exposure standards. Sampling information is presented to assist industrial hygienists when they encounter circumstances discussed in the Sampling Strategy section.

f. It is important to cleanup and remediate the affected area(s) as necessary.

3. Investigator Protection

a. Do not disturb contaminated areas or aerosolize biological material.

b. Do not touch visibly contaminated areas with your bare hands. If you do, wash thoroughly with soap and water as soon as possible.

c. If you must perform destructive sampling in an area (i.e., remove a section of wallboard to access the wall cavity) or disturb a substrate that you suspect is contaminated, use appropriate personal protective equipment (PPE) and lightly spray surfaces with amended water (contains a surfactant) to minimize the possibility of aerosolizing spores.

d. Recommended PPE for those assessing and/or sampling contaminated areas includes disposable gloves; disposable coveralls; goggles; NIOSH approved half face N-95 respirator (disposable is okay). PPE for remediation projects is discussed in Chapter 13 Section 3.

4. Communication

a. The principles and techniques learned in risk communication training are essential for biological contamination projects.

b. The more informed occupants are about what is happening, the less likely they are to be fearful. When mold or other biological contaminants are found, it is important to make sure that occupants are fully informed. Tell them in simple terms what has been found and what will be done to correct the building problems. If remediation is required, tell occupants what will be done, give them the remediation schedule and explain how they may be affected (e.g., temporary relocation, control measures, testing). Provide medical support from the cognizant clinic for those with medical concerns or those who develop symptoms they believe to be associated with the contamination. Answer questions honestly and calmly, provide facts sheets tailored to the situation, and provide a contact list by name for medical, IH and remediation issues, so occupants can call if they have

concerns. Involving occupants in the process gives them a stake in the successful outcome. Chapter 13 Section 5 contains a detailed discussion of risk communication.

5. Assessment Strategy

a. Visual Inspection.
   (1) Always conduct a thorough visual inspection first, evaluating the building with a critical eye toward potential problem sources. Look for signs of water damage on the ceiling, walls and floors. Inspect the ventilation system (air handling unit, ducts, fresh air intake location, dampers). Locate odor sources and look for possible chemical and biological contaminant sources or reservoirs.
   (2) Likely sources or areas to check for water leaks include the roof, loose or damaged soffits and gutters, chimneys, through-roof pipes or vents, improperly sloped drains, improper grading or poor drainage around the outside of the building, improperly vented appliances, uncontrolled humidity (e.g., moisture condensing on surfaces), and improperly installed vapor/moisture barriers or surface finishes (e.g., exterior insulation and finish system (EIFS) or unsealed stucco).
   (3) Simple tests may be helpful to determine the extent of damage or contamination. For example, a borescope can be used to check the condition of ventilation ducts. A moisture meter can quickly identify wet building materials. Assessing indoor thermal conditions such as temperature and relative humidity, as discussed in Chapter 13 Section 1, can also help identify areas where mold reservoirs are likely.
   (4) If visible mold is found, locate the source of water and repair to prevent additional intrusion and water damage. Proceed with cleanup and remediation procedures, as discussed in Chapter 13 Section 3.
   (5) If mold is not found during the visual inspection, but the team believes there is biological contamination in the building (because of odors, visible water damage, occupant illnesses, etc.), take additional investigative steps.

b. Additional Investigation.
   (1) Review building plans and check maintenance and preventive maintenance schedules for possible relations between mechanical component locations, maintenance procedures and complaints.
   (2) Talk with occupants about their complaints and symptoms, especially anything different or unusual in the building that they may have noticed, or whether they detected any pattern in their symptoms or with problems in the building.
   (3) Check the building's relation to nearby industrial operations for potential pathways that might introduce contaminants.
   (4) Investigate for possible hidden mold reservoirs. This may require destructive procedures, such as removing wall coverings, wallboard, carpet or floor covering. Consider that there might be concealed growth behind walls, paneling or wallpaper, under floors, in electrical or plumbing chases, in ducts, etc.
      (a) Collecting screening air samples can help locate the general area of hidden mold reservoirs. Consider sampling for viable or non-viable bioaerosols (fungal

spores), glucans, ergosterol, total microbial volatile organic compounds (MVOCs) or mycotoxins.

(b) If mold is found, locate the source of water and repair to prevent additional intrusion and water damage. Proceed with cleanup and remediation procedures, as discussed in Chapter 13 Section 3.

(5) Investigate and test for other possible biological contaminants. This might include sampling for bacteria, endotoxins, allergens (mites, dander, etc.) or checking on neurosensory factors (e.g., visual or perception disruptors).

6. Sampling Strategy

a. Do not recommend sampling for mold before consulting with NMCPHC IH and/or the Risk Communication Department.

b. Concurrence on why and when to sample should be made between the local Military Treatment Facility (MTF) IH program office and supporting NAVFACENGCOM office. If it is determined that sampling would be beneficial then NAVFACENGCOM should be the lead on any contract development.

c. Do not collect samples without a sampling plan that details how and when samples will be taken, collection requirements for each type of sample, what criteria will be used to interpret results, and what benefits you expect from sampling (i.e., what question(s) will be answered and what actions will result).

d. Always consult the analytical laboratory before sampling to ensure sample collection and shipping are done per the laboratory's requirements and that results will meet your expectations. Analytical laboratories are discussed further later in this document.

e. When to Sample

(1) The rule of thumb in biological contamination investigations is do not sample when visible mold is present. Regardless of the mold identified or the number of spores, it does not change the requirement to stop the water intrusion and clean up the contamination. This is probably one of the biggest challenges during the investigation, since sampling is a natural action for industrial hygienists and a normal expectation from occupants.

(2) If you cannot collect a sufficient number of samples to fully characterize the site (i.e., because of funding constraints or insufficient sampling media), it is probably best not to collect any samples. Inadequate sample data usually leads to misleading or confusing results.

(3) The investigation team should be guided by their collective expertise in deciding whether sampling is indicated. The following are some situations in which sampling is indicated:

(a) If an occupant has been diagnosed with a disease that is caused by a specific biological contaminant or the physician suspects an association between symptoms and biological contaminant in the workplace, the physician may request confirmation of the presence of the causative agent.

(b) If remediation is required, pre- and post-remediation sampling can be used to verify success of the decontamination. Surface samples are especially useful.
(c) If the investigation team suspects biological contamination but cannot find evidence such as visible mold, air sampling may help to verify or locate hidden contamination. In such cases, air sampling could include testing for bioaerosols (viable and/or non-viable such as fungi or bacteria), glucans, ergosterol, Microbial Volatile Organic Compounds (MVOCs), mycotoxins, endotoxins or allergens.
(d) If litigation is underway or anticipated.
(e) If the ventilation system was cleaned/remediated because of biological contamination (verified by visual or bulk/swab samples), use air sampling to determine if the areas supplied by the system are ready to reoccupy (i.e., the ventilation system is no longer a source of bioaerosols).

(4) Because you may be sampling biological contaminants such as mold whose presence depends on environmental conditions (heat, light, water availability), carefully consider the seasons and ambient weather conditions.
(a) Rain can "wash" the air clean of many spore types, such that sampling on rainy, foggy, or very humid days can result in low outdoor counts or species distributions that are significantly different from those on warm, sunny days. However, in general, levels of ascospores and basidiospores will be higher during rainy weather.
(b) Sampling when there are strong winds can result in outside spore counts that are significantly higher than on non-windy days. In addition, high outdoor spore counts may mask small to moderate indoor mold problems since interpretation is dependent in part on ratios of indoor to outdoor spore counts.
(c) Compensate for ambient conditions by adjusting your sampling schedule if possible. At least be aware that outside samples may not represent normal conditions so that you do not misinterpret results.

f. Where to Sample.
(1) Complaint/Problem Area. Use complaint patterns, symptom descriptions and visual indications to guide you in choosing sample locations. You may need a sampling array within a single office, on an entire floor of the building or throughout the building to get results that are representative. Preliminary or screening samples may help target the areas that require further characterization.
(2) Non-Complaint Area. Non-complaint area results serve as controls to compare with complaint area results.
(3) Outside. Outside samples must be taken at the same time as indoor samples so that the types and quantities of ambient flora can be compared with those in the building. Ideally, at least one outside sample is collected at the fresh air intake that supplies the inside area being sampled.

g. Number of Samples.

(1) There is no formula to determine how many samples you need to characterize adequately a complaint area. Further, statistical validity considerations cannot be used because of the difficulty in predicting the environmental variability. Reference 13.2-1 gives the following guidance:

(a) The number of samples depends on the size and organization of the space being investigated.

(b) Sample as many locations within the area of study, control locations and outdoors as is practically and economically feasible.

(c) When possible, take duplicate side-by-side samples. According to Reference 13.2-1, "duplicate side-by-side sampling is considered adequate to define the mean and the random sampling and analysis error given the high temporal and spatial variability of bioaerosol concentrations in air." "Acceptability of the agreement between side-by-side duplicate samples must be determined by the investigator based on the intended use of the data."

(d) Investigate temporal variations by sampling at least two time periods during the day, preferably separated by a long interval, e.g., morning and late afternoon. Sample on different days or during different seasons if daily/seasonal variations appear to influence conditions.

h. Choosing What and How to Sample.

(1) Fungi, Bacteria, Allergens and Other General Biological Contaminants.

(a) Viable (Culturable) vs. Non-Viable (Non-Culturable) Samples.

1. Viable samples (fungi, bacteria, etc.) are typically collected on nutrient agar initially, or can be collected in/on inert media (impinger liquids, filters, vials, bulk collectors, swabs) and prepared for culture at the laboratory. Samples are incubated for several days to allow cell growth and replication into visible colonies. The entire colony is used for the identification, allowing the laboratory to make a more exacting identification of certain types.

a. Culturable samples tend to underestimate the number of total cells present, since only viable organisms will grow. In addition, of the viable fungi or bacteria that impact onto the agar during sampling, only a percentage of those will actually grow during incubation.

b. Further, remember that some organisms require specific nutrients or growing conditions. If these are not present, the organism will grow very slowly or not at all. For example, Stachybotrys requires cellulose. If you use Malt Extract Agar (MEA) for sampling and the report shows no Stachybotrys, this means that there really was no Stachybotrys in the sampled area or Stachybotrys was present but MEA did not support its growth. A better alternative, in this case, is to collect a non-viable sample since the spores are very distinctive and can easily be identified by direct microscopic examination. For sampling any organisms, contact the laboratory to determine the nutrient agar of choice for collecting viable samples.

c. Some sampling methods work better than others for viable samples depending on what you wish to find. For example, the recovery of viable fungi is typically much better than the recovery of viable bacteria using filtration methods with standard filters. This is due to bacterial cell desiccation. You can increase viable bacteria recovery using filtration methods by using a gelatin filter.

2. Non-viable samples (fungi, pollen, mycelia, fiber, skin cells, fiberglass, etc.) can be collected in/on a variety of media (impinger liquids, sticky tape/slides, filters, vials, bulk collectors, swabs) and are examined directly under a microscope to identify and count spores (genus identification) and other particulates (e.g., mycelial fragments, fibers, skin cells) based on morphological features.
   a. Some molds, such as Aspergillus and Penicillium, cannot be distinguished by their spores alone, so they are reported as a group (e.g., Aspergillus/ Penicillium group; Drechslera/Bipolaris group; or Smuts/Periconia/Myxomycetes.

(b) Allergens. Allergens can be viable and/or non-viable biological contaminants that produce allergic reactions in sensitive individuals. Typical allergens that are analyzed are produced by dogs, cats, rats, mice, cockroaches, dust mites and some fungi. Allergens can be collected in/on a variety of media (impinger liquids, filters, bulk collectors, and swabs) and are analyzed by fluorescent immunoassay, enzyme immunoassay (ELISA), radioimmunoassay (RAST) or Multiplex Array for Indoor Allergens (MARIA). These analyses are based on the specificity of an antigen-antibody reaction. Cross-reactivity can occur.

(c) Fungi and Bacteria (Genetic Identification). Some fungi and bacteria can now be identified by Polymerase Chain Reaction (PCR) analysis. These samples can be collected in/on a variety of media (impinger liquids, filters, bulk collectors, swabs). This analysis provides genetic confirmation of certain fungal and bacterial species using species-specific DNA probes or primers. PCR is specific, but the technology is limited to the species probes available for fungal and bacterial confirmation. Consult the individual laboratories that offer PCR to determine what fungi and bacteria are in their detection panels.

(d) Fungal and Bacterial Metabolites and Cell Components.

1. β – Glucans and Ergosterol.
   a. Both (1,3)-β-D-glucan (glucans) and ergosterol are fungal cell wall components of filamentous fungi, which includes most saprophytes. Sampling will detect these components in both living and dead spores. These compounds have been sampled successfully as chemical markers to show that such fungi are present. There is little data comparing the number or mass of spores to chemical marker concentrations.
   b. Glucans are collected by filtration and are extracted and analyzed using limulus amoebocyte lysate (LAL) or ELISA.

c. Ergosterol is also collected by filtration and is extracted and analyzed by high performance liquid chromatography (HPLC), gas chromatography (GC) or GC with mass spectrophotometry (MS). Ergosterol is reasonably stable in spores.

2. Endotoxins. Endotoxins are found in the cell walls of gram negative bacteria. Made of lipopolysaccharides, they can elicit health effects in susceptible individuals whether the bacteria is viable or not. The most common exposure routes are inhalation and ingestion. Gram negative bacteria are most often associated with water, sewage, humidifiers and gray/black water contamination. Endotoxins are collected on endotoxins-free filter cassettes or by bulk sampling. The samples must be collected carefully to ensure there is no contamination. Analysis can be done by LAL, kinetic chromogenic assay or turbidimetric assay.
3. Extracellular Polysaccharides (EPS). EPSs are stable carbohydrates that are produced during fungal growth. EPSs have antigenic specificity, usually at the genus level and are analyzed by ELISA immunoassay.
4. Fatty Acids. - Fatty acids are bacterial cell wall components. Analysis uses GC, or GC-MS to determine the fatty acid profile, then compares results to a reference database using statistical pattern recognition software.
5. Microbial Volatile Organic Compounds (MVOCs). - MVOCs are produced by fungi and bacteria that are metabolically active. They are also responsible for many of the musty odors associated with molds. If you 'smell mold' but cannot see it, MVOC sampling may help to locate the fungal reservoir. MVOCs are collected using sorbent tubes or summa canisters and analyzed by GC or GC/MS.
6. Mycotoxins
   a. Fungi are primarily saprophytic, that is, they use nonliving organic material as the nutrient source for growth and reproduction. During the digestion process, fungi secrete enzymes to help break down complex compounds into simpler ones that can be taken up and digested. The by-products of digestion are classified as primary or secondary metabolites. Primary metabolites are produced from cellulose and other compounds that are used by the fungus for energy, growth and reproduction. Secondary metabolites are natural by-products that are not necessary for growth and are usually derived from precursors formed during primary metabolism. One type of secondary metabolite is mycotoxins. Only some species of molds produce mycotoxins and they usually only produce them some of the time. Mycotoxins are thought to give the fungi a competitive edge against other microorganisms, including other fungi. Whether a toxigenic fungus actually produces mycotoxins appears to depend on environmental conditions, including temperature, moisture, growth substrate, aeration, pH and existing stress factors. Some of the

mycotoxins most commonly associated with mold contamination in buildings are briefly described in Appendix 13.2-A.

b. Mycotoxins accumulate in spores, mycelium and growth substrates. Consequently, they can be inhaled (when spores or substrates are disturbed and aerosolized), ingested (consuming toxin-containing spores when eating, drinking or smoking in a contaminated area), or absorbed through the skin (when handling contaminated materials). Mycotoxins are generally nonvolatile and so are not inhaled directly (i.e., they do not off-gas).

c. Because air sampling for mycotoxins has limitations, bulk or surface samples are usually best. Mycotoxin samples can be collected in/on a variety of media (filters, bulk collectors, swabs) and are analyzed by liquid chromatography (LC) with MS, HPLC, GC-MS, solution fluorimetry or ELISA immunoassay.

i. Choosing the Appropriate Type of Sample (Air, Bulk or Surface) and Sampling Methods

(1) Before taking a sample, think about why you need the result and what you want the results to tell you. For example, if you are trying to determine if an area is contaminated or if what you see is really mold, a swab or bulk sample may be sufficient.

(2) Appendix 13.2-B summarizes various sampling methods based on analyte. However, not all products available may be included. Appendix 13.2-B is meant as an overview of various sampling methods to assist Navy industrial hygienists. It does not imply endorsement by the Department of Defense (DoD), the Navy or the NMCPHC of particular methods, nor does it mean that this resource content has been validated. Consult the laboratory that you will be using to perform the analysis for specific sampling methods, procedures and equipment.

(a) Air samples. Air sampling is the most common collection method for bioaerosols. A pump is used to draw in air and deposit the particulate onto a collection medium. Various air sampling methods can be used for microscopic analysis, culturing techniques and/or specialized testing. Each kind of air sample has its benefits and disadvantages, depending on the media used and the collection and analytical method chosen. Regardless, air sample results for molds and other bioaerosols are subject to false negative results. That is, there may be contamination present even when results indicate otherwise.

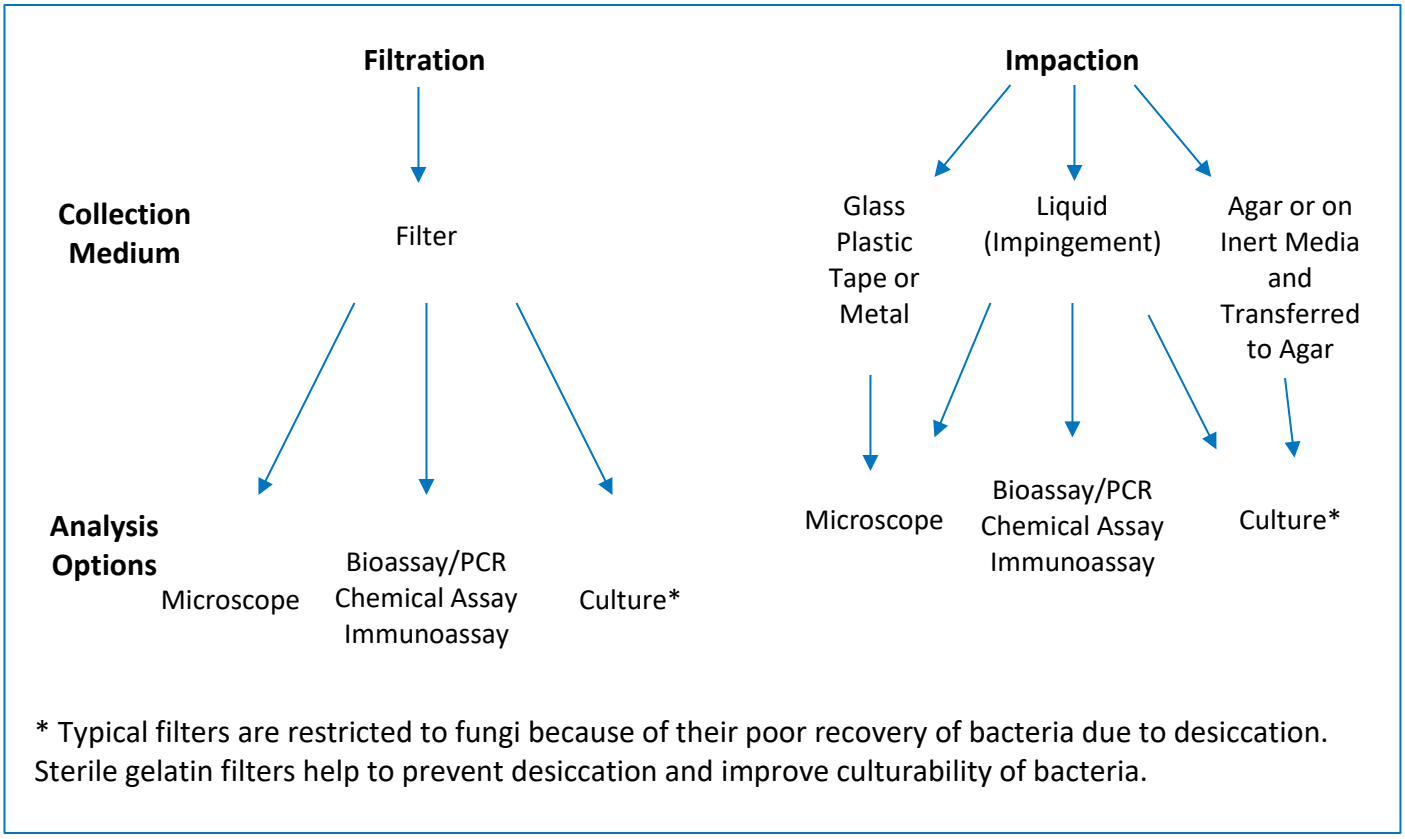
1. Bioaerosol Collection Principles for Air Sampling. In general, collecting bioaerosols involves either filtration or impaction. Figure 13.2-1 shows the collection methods and the possible analyses that can be performed using each.

a. Filtration. Bioaerosol is collected on a filter as air passes through it. Filter media can have different diameters, pore sizes and composition, so consult the laboratory before sampling.

b. Impaction. Bioaerosol is impacted onto a collection media such as glass or plastic slides (may contain collection strip of agar, grease, adhesive or

tape), glass vials, metal impactors, liquid or agar plates. Impaction into a liquid medium is also called impingement.

Figure 13.2-1. Bioaerosol Collection Methods.



* Typical filters are restricted to fungi because of their poor recovery of bacteria due to desiccation. Sterile gelatin filters help to prevent desiccation and improve culturability of bacteria.

2. Why Mold Size is Important. Particle collection efficiency is driven by the size of the particle you want to collect. With spores, this can make the difference in whether a negative result means there is no mold present, or that the mold is there but you did not collect it. For example, Cladosporium cladosporoides is around 2 µm in size. If you suspect that you have cladosporoides contamination and you sample using a collection device that is inefficient at 2 µm sizes, you could get negative results because you would miss most if not all of the spores. When contacting a laboratory or a vendor about sample collection methods and equipment, pay particular attention to particle size cut points and collection efficiencies.

(b) Bulk Samples. Bulk samples can be used, especially when trying to locate or confirm the presence of mold as a causative agent for medical diagnosis. The sample is analyzed by direct microscopic examination to determine if there is biological contamination. Bulk samples can also be cultured for identification. Examples of materials that might be collected include carpet, insulation, duct lining, wallpaper, wallboard (sheetrock), liquids from HVAC systems and dust.

1. Solid bulk samples can be collected from visibly contaminated surfaces by scraping or cutting with clean tools (e.g., wall board). Place sample in a sterile container (plastic bag, glass or plastic vial) seal tightly and label for transport.
2. Bulk water samples can be collected from condensate drain pans, cooling towers (i.e., for Legionella) or other water reservoirs suspected of being a contaminant source. Collect in a sterile container, seal tightly and transport in a secondary container (such as a sealable plastic bag) to contain the sample in case of breakage or leaks.
3. Bulk dust samples can be taken using a microvacuum. This is essentially a cassette attached to a pump that is used to vacuum carpets, furniture or other substrates to collect the particulate matter. Though the sample can be randomly vacuumed into the cassette, using a specific grid collection area will allow quantitative results. This type of bulk sampling is often done on carpets.

(c) Surface Samples.

1. Surfaces can be sampled by swabbing or using clear cellophane tape (also called a sticky tape sample). The sample is analyzed by direct microscopic examination to determine if there is biological contamination. Sterile swab collections can also be cultured for identification. Surface sampling is limited to identifying settled fungi or spores and may not be related to air sample results. Sticky tape sample results provide spore identification to the genus level only.
2. Settling plates/gravity plates are open nutrient agar Petri dishes. They are placed on a flat surface to collect anything that settles out of the air. Results are not particularly meaningful, since what grows depends on random settling of airborne particulates onto a non-specific growth medium. Navy personnel will not typically use this method.

(3) General Sampling Tips.

(a) You must decide whether you want viable or non-viable analysis or other specialized testing before you sample.

(b) Before collecting any samples, select the analytical laboratory you will use. Call the laboratory to ensure that you sample according to their requirements. In some cases, the laboratory may provide the sample collection equipment. For example, a laboratory might loan you an Andersen N6 and provide the correct agar for the targeted biological population.

(c) Sampling conditions should be reflective of normal building conditions. The ventilation system should be on the usual daily setting (e.g., temperature, damper opening(s), setbacks, auxiliary/booster fan operation, fresh air intake settings) and occupants should work as they typically do. Do not intentionally alter the area to be sampled.

(d) Sample on different days and at different times of the day to get samples that represent conditions over time. Replicate samples are a good idea to increase

confidence in your results. Remember that results tend to be less reliable or repeatable when sample times are very short.

(e) Aggressive sampling is not recommended for investigational studies. While aggressive techniques will disturb accessible biological contaminants, it complicates result interpretation because it is not representative of normal building conditions.

(f) Record ambient conditions during sample collection, such as temperature and relative humidity. Also, make notations of conditions inside that may affect results, such as obvious water damage or contamination in relation to the sample location; potential microbial reservoirs, like fish tanks, plants or trash; condition of HVAC system components; presence of pets; or open/leaky doors and windows. Outside sample notes should include weather conditions (cloud cover, recent precipitation, wind, etc.) and locations of land features (ditches or standing water, landfills, playgrounds, construction areas, etc.).

(g) It is prudent to use a chain of custody (COC) form with your samples. The COC is particularly important should you become involved in litigation but should be used anyway to track the samples' journey from collection to analysis. If you do not have a COC form, most laboratories will supply you with one. You can view examples at the sites listed below. This is not an endorsement of particular products or vendors, and does not imply endorsement by the DoD, the Navy or the NMCPHC, nor does it mean that these resources' content have been validated.

1. https://www.aerobiology.net/wp-content/uploads/2017/01/2017-COC-Editable.pdf
2. http://www.emlab.com/media/resources/submit.pdf
3. https://www.emsl.com/ChainOfCustody.aspx
4. http://www.testamericainc.com/services-we-offer/services-we-offer-by-sample-matrix/air/industrial-hygiene-analysis-and-equipment-rental/industrial-hygiene-chain-of-custody-document

7. Having the Samples Analyzed

a. The Comprehensive Industrial Hygiene Laboratories (CIHLs) do not analyze samples for air pollution and water pollution under Environmental Protection Agency (EPA) jurisdiction nor do they analyze environmental samples for bacteria and fungi collected as part of an IEQ investigation. For environmental analysis under EPA and state permits, you should contact your local NAVFACENGCOM Environmental Office.

b. Use only analytical laboratories that are proficient in the American Industrial Hygiene association (AIHA) Environmental Microbiology Proficiency Analytical Testing (EMPAT) program and accredited by the AIHA Environmental Microbiology Laboratory Accreditation Program (EMLAP).

(1) The EMPAT evaluates the laboratory's ability to identify cultured fungi and bacteria and/or fungal spores that might be found in mold contamination investigations

correctly. The EMPAT certificate states whether the proficiency is for cultured identification of bacteria, fungi, or both, or for direct exam of fungal spores.

(a) Under the current EMPAT culturable program, laboratories must correctly identify the genus. Speciation is optional in the culturable program, but it is strongly encouraged. Speciation is weighted but is not necessary in order to achieve and maintain proficiency.

(b) The EMPAT direct exam program is targeted towards participants analyzing fungal spores by light microscopy. Participating in the direct exam program enables participants primarily performing spore trap analysis to establish proficiency and improve performance in the microscopic analysis of environmental samples.

(c) At this time, proficiency testing does not involve counting (of spores or colonies) or identifying organisms from mixed cultures.

(d) Beware of laboratories that advertise that they participate in the EMPAT rather than that they are proficient in the EMPAT. For the most current information, consult the AIHA web site.

(2) The EMLAP assesses and rates various laboratory parameters, such as personnel qualifications, EMPAT scores (performance), facilities, quality assurance programs, record- keeping, analytical methods and operating procedures. EMLAP also includes biennial site visits to the laboratory.

(a) Laboratories can become accredited in one or more fields of testing (FoT):

	FUNGAL By Laboratory Culture	BACTERIAL By Laboratory Culture	FUNGAL By Direct Examination
FoT	Air	Air	Air
	Bulk	Bulk	Bulk
	Surface	Surface	Surface

(b) For the most current information, consult the AIHA web site.

(c) A list of accredited laboratories is provided on the AIHA web site. This list shows points of contact for the laboratories and the FoTs and methods in which the laboratories are accredited. Please consult directly with the laboratories for more specific information on analysis methods, and for information on additional analyses (Allergens, Endotoxins, Mycotoxins, MVOCs, etc.) and services available that are not listed on the accreditation.

c. Always check with the laboratory to confirm what services are available and what procedures should be followed. Define sample collection methods, procedures and equipment and how samples should be transported.

d. Always check with the laboratory to confirm turnaround time and what is included in the cost. Some laboratories might offer sample collection equipment loan or rental programs if you use their analytical services. Some laboratories might include collection

media (especially agar plates for viable sampling) in the analysis cost whereas others require you to purchase media separately. Furthermore, make sure that you know what the laboratory includes with their analysis. For example, if you submit a viable sample collected with an Andersen N6 impactor, will the lab identify all microorganisms or only the predominant 3? Or 5? Will the report include genus and species identification or only the genus? Will the laboratory clearly report genus and spore count or spore concentration (e.g., Cladosporium 450 spores/m^3 or as Cladosporium-like (not definitive for Cladosporium but spores look similar) or Cladosporium 42 spores (you must calculate concentration))? Also, some laboratory reports include interpretive guidance. Some will not give any explanation and still others will interpret your results for an additional fee.

8. Interpreting Results

a. The presence of mold or other biological contaminants does not mean that occupants will have adverse health effects or that they will even be exposed. Like any other stressor, you must have a completed exposure pathway to the contaminant. The mold or mold fragments, spores, bacteria, metabolites or allergens must be produced, released, reach the occupants, then be inhaled, physically contacted or ingested. Even after contact, human response will depend on individual susceptibility (e.g., genetic predispositions to allergens, age, health status) and type of exposure (allergen, toxin, infectious agent).

b. There are no standards for biological sample results. The AIHA, American Conference of Governmental Industrial Hygienists (ACGIH), EPA and numerous other resources agree that the best criteria for interpreting results is to compare inside samples with outside samples, and/or contaminated areas with uncontaminated areas, along with consideration of both the kinds of biological contaminants present (such as molds genus/species) and the numbers (quantitative assessments). The following are some interpretation criteria and considerations regarding molds.

(1) Interpretation Criteria for Molds.

(a) An effective interpretation is based on comparing inside and outside sample results. In general, inside counts should be around 30-80% of outside and have the same general distribution of genera.

(b) The relative rank order of the genera/species results inside should be similar to outside. If the dominant types of mold in indoor samples are not the same as those in outdoor samples, it indicates an indoor mold source.

(c) The concentration of each genus/species identified inside should be less than outside. Higher inside levels indicate there is fungal amplification indoors.

(d) The presence or absence of a few genera in small numbers should not be considered abnormal.

(e) Normal outside fungi typically include Cladosporium, Alternaria, Epicoccum and Basidiomycetes, so it is common to see these identified in indoor samples.

(f) The presence of certain fungi indoors should prompt immediate risk management decisions. Examples of fungi of concern include Aspergillus versicolor, Aspergillus flavus, Aspergillus fumigatus, Stachybotrys chartarum, Fusarium moniliforme, Histoplasma and Cryptococcus.

(g) Numerical guidelines can be useful as a secondary interpretive resource when evaluating viable fungi sample results (i.e., reported in colony forming units per cubic meter of air (CFU/m^3)). The following limits, from Reference 13.2-2, provide some advice on how to interpret air sampling results for mold from sampling in large office buildings. It includes some numerical limits for spore counts in CFU/m^3. These are often misinterpreted as Health Canada guidelines. However, the numbers show typical values found in sampling done in federal government buildings by the author, using a specific sampling method. They are meant to help guide investigations in office buildings where mold is suspected but not located by visual inspection. According to Health Canada, “They do not represent a "safe level" of mold, are not applicable to homes and in no way represent an official Health Canada guideline or recommendation.” Therefore, fungi levels more than these numbers do not mean that the conditions are unsafe or hazardous. Additionally, do not use these limits for non-viable fungi sampling results.

1. <150 CFU/m^3 total fungi is acceptable if the reported genera are reflective of normal outdoor flora (e.g., Cladosporium and other leaf and tree fungi). Higher counts suggest dirty or low efficiency air filters or other problems.
2. <500 CFU/m^3 total fungi is acceptable in summer if the reported genera are reflective of normal outdoor flora. Values higher than this may indicate failure of the filters or contamination in the building
3. >50 CFU/m^3 of a single species other than Cladosporium or Alternaria should prompt further investigation.

(2) Consider Outside Air Entry.

(a) Filtered or conditioned air will affect the relative numbers of genera. In an office building with little fresh outside air or poor air exchange rates, ‘normal’ inside counts may be very low (i.e., 2-5% of outside). The rank order of genera should be similar.

(b) If sampling in a building or residence when doors and/or windows are open, expect ‘normal’ inside counts to be very similar to outside (i.e., as high as 95%). The rank order of genera should be similar.

(3) Put Results in Context with Other Facts.

(a) On microscopic examination, morphologically similar spores cannot be differentiated. The most common example of this is with Aspergillus, Penicillium, Gliocladium, Trichoderma and other small, round, colorless spores. Non-Viable sample results will report all such spores as Aspergillus/Penicillium group.

1. If non-viable sample results show high indoor counts of Aspergillus/Penicillium, you may want to collect viable samples for culture to

separate the genera and determine which species of Aspergillus is present since several produce mycotoxins and are infectious.

2. Myxomycetes/Rust/Smut or Smuts/Periconia/Myxomycetes will also be reported together on non-viable sample reports. These are morphologically similar round, brown spores that are common outdoor plant molds.

(b) The presence of fungal fragments such as hyphae or conidiophores suggests colonization, growth or accumulation of fungi in the sampling location.

(c) The presence of yeast suggests wet conditions.

(d) Be sure you know the ambient sampling conditions before using outside sample results.

1. Outside samples collected during or soon after rain will usually have lower total spore counts but higher relative concentrations of ascospores and basidiospores.
2. Expect higher concentrations of fungi in warmer weather and lower total counts in cooler weather.

9. References

13.2-1. American Industrial Hygiene Association (AIHA). Field Guide for the Determination of Biological Contaminants in Environmental Samples. AIHA. 2005.

13.2-2. Health Canada. *Indoor Air Quality in Office Buildings: A Technical Guide.* Health Canada. 1995.

Section Three – Mold Cleanup, Remediation and Clearance Sampling

1. General

a. The following information in this section is provided to the industrial hygienist for their knowledge when responding to queries concerning mold remediation response. The information should not be misinterpreted to indicate that mold remediation is the responsibility of IH. The responsibility for mold remediation planning and execution rests with the local facilities management office (see Chapter 13 Section 1).

b. The previous section stressed that prevention is the best policy: if water does not get into the building, mold will not grow. However, if you do find mold, it is crucial that you know how to remove the contamination safely and effectively and to assess the project success. Be prepared to review contract requirements, oversee the remediation or liaise with occupants about associated concerns.

c. This section is a compilation of the most widely practiced mold remediation guidance, using the New York City Department of Health Guidelines on Assessment and Remediation of Fungi in Indoor Environments (Reference 13.3-1) and Environmental

Protection Agency's (EPA's) Mold Remediation and Schools and Commercial Buildings (Reference 13.3-2) and several other documents are also incorporated.

d. Also, consult United Facilities Criteria UFC 3-810-01N, Navy and Marine Corps Environmental Engineering for Facility Construction (Reference 13.3-3) and United Facilities Guide Specifications (UFGS) 02 85 00.00 20, Mold Remediation (Reference 13.3-4) for additional specific information.

e. Other references may cite different or additional recommendations for cleaning and remediation procedures.

f. Facilities where sensitive populations are found (e.g., hospitals treatment areas, day care centers or nursing homes) might require a more conservative approach.

g. These guidelines are not intended for use in critical care facilities, such as intensive care units, transplant units or surgical suites.

2. "Rules" For Response and Remediation

a. Act Quickly. Rapid response and proper actions following water damage are essential to significantly reduce or even prevent microbial damage. Ideally, response actions following water intrusion should begin within 8 hours. Response within 24 hours will usually prevent mold growth. If actions are not underway within 48 hours, chances are good that mold will grow in or on water damaged materials and some level of remediation will be needed.

b. Locate and Fix Water Intrusion Source(s). This is essential to stop additional water infiltration and damage. Make repairs before or concurrent with removing water and drying the area.
   (1) Likely sources to check as water intrusion points include: the roof (missing or damaged shingles/finish or flashing); loose or damaged soffits and gutters; chimneys; through-roof pipes or vents; improperly sloped drains; improperly vented appliances; uncontrolled humidity (i.e., moisture condenses on inside surfaces); improperly installed vapor/moisture barriers or surface finishes (e.g., exterior insulation and finish system (EIFS) or unsealed stucco); poorly fitted or sealed windows; crawlspace, slab or other foundation material (standing water or episodic incursion from rising water table); heating and cooling system; visible signs of flooding or recurrent water damage.

c. Remove the Water and Protect Materials. Some actions that might prove useful include:
   (1) Water can be removed from hard surfaces by soaking it up or mopping. If large volumes of water are in the building, it may be necessary to actively pump out standing water and/or use wet vacuums.
   (2) Remove all wet carpet, rugs and padding.
   (3) Remove wall moldings (baseboard, decorative trim) to allow drainage if water has entered the wall cavity.

(4) Drill holes in the wallboard to facilitate drying inside the wall cavities. Remove wet wallboard. This allows you to assess wall cavity damage, determine when structural components are dry and removes a likely growth substrate for mold.
(5) If built-in cabinets are wet, remove kick plates or drill holes for drying.
(6) Check for water in the ventilation ducts, pipe chases, crawl spaces, basements and attics.
(7) Consider moving wet furnishings and items outside (weather permitting) or to a separate dry location. This can decrease dry time since you are not trying to dry out the furniture and the room simultaneously.
(8) Furnishings and other building contents that are not wet or damaged by the water intrusion should be moved temporarily to a dry location. If such items cannot be moved, protect them as much as possible (e.g., by covering in plastic if water is still leaking into the area or by elevating off the floor to remove from direct water contact).

d. Dry the Area to Control Humidity and Temperature. Once excess water is removed, use fans/air moving devices to promote evaporation and help drive off remaining moisture from furnishings and building materials. This step, in turn, increases the amount of moisture in the air, which must be removed by using dehumidifiers or by actively exhausting air outside. Take care to ensure that partially dried areas and/or those not initially damaged by water are stabilized as other wet areas are being processed. Generally, relative humidity levels <60% will inhibit mold growth.
(1) If weather permits, move wet furnishings outside to help with drying. If this is not possible, consider moving wet furnishings and items to a separate dry location. This can decrease dry time since you are not trying to dry out the furniture and the room simultaneously.
(2) Do not use any building ventilation systems unless you have confirmed that they are not damaged, contaminated or electrically compromised (i.e., wiring damage or electrical hazards).
(3) There are two basic types of drying systems: open and closed.
(a) An open or natural dehumidification system exchanges the moist air inside the structure with dryer air from outside. For example, if outside conditions are favorable (i.e., relative humidity less than about 40% with moderate temperatures), opening windows and doors and continuously ventilating the area with air movers, building exhaust fans and/or ceiling fans will speed the drying process.
(b) A closed or mechanical system uses equipment to remove the evaporated water from the remediation area. Be careful to ensure that the dehumidification rate does not go below the evaporation rate or you will slow drying time and may actually cause additional damage. Controlling the temperature in the building will enhance both evaporation and dehumidification efforts.
(4) You should routinely check the temperature, relative humidity and material moisture to monitor drying progress. A moisture meter is essential for determining the status of structural components and furnishings.

e. Clean the Area. Remove Mold if Required.
   (1) Once water is removed, assess remaining structural materials and building contents to determine what can be saved. The general rule is to remove all porous materials that were/are wet or damaged. Use a mild detergent and water solution to clean non-porous materials.
   (2) If mold is visible or materials have been wet longer than 48 hours, more extensive actions are needed to ensure that mold is completely removed and unlikely to reappear.
      (a) Mold removal plans must be approved by the cognizant IH, safety and facilities personnel.
      (b) As a minimum, the mold removal plan should specify exactly what will be done during remediation, how it will be accomplished, acceptable criteria for re-occupancy and required sampling procedures (if any) and how to interpret results. For example, include detailed removal procedures; protective equipment for remediators; type of containments; contaminated material disposal; special cleaning requirements (books, carpet); sampling method(s) and interpretation criteria if any sampling is required; employee relocation requirements if needed; and risk communication plan (e.g., meetings with employees, method and frequency of status reports to employees and management, points of contact).
      (c) Killing mold is not enough. Because residual biomass can still elicit allergenic responses from sensitive individuals, mold must be removed.
   (3) The cleanup and remediation guidance in this section applies only when the contamination results from clean water intrusion, such as broken water supply lines, roof or window leaks or condensate from high relative humidity. Cleanup of gray water (contains some contamination such as from a dishwasher or washing machine overflows; toilet overflow with no feces) or black water (unsanitary, pathogenic water source such as sewage or storm flooding) requires more extensive procedures and protection because of the unsanitary conditions.
   (4) All procedures discussed in this section are minimum recommendations for cleaning and/or decontaminating materials that have been subjected to clean water damage, including building contents, ventilation systems and structural components. The investigative team may recommend more stringent procedures based on actual conditions at the site.

f. Ensure Personnel Protection and Communication
   (1) A successful remediation means that visible mold and mold damaged materials are removed without exposing personnel or releasing any of the contamination to other parts of the building or to the environment. Protect personnel including occupants and remediation personnel. Protection is discussed in detail later in this section.
   (2) A critical component of the assessment phase is open and honest communication and information exchange between the investigators, managers and occupants. This is even more important during remediation. People need assurance that their work environment is safe and that they are not exposed to the mold during cleaning or

removal procedures. Inform occupants of exactly what will occur during remediation and what precautions are in place to protect them.

g. Follow Up. After cleanup/remediation is complete, revisit the area periodically to ensure that leak repairs were effective, materials are still dry and there are no signs of water damage or visible mold growth. People should be able to occupy the space without experiencing mold related health complaints and associated physical symptoms.

3. Cleaning and Remediation Procedures

a. General Considerations.
   (1) In most cases, at least some kind of cleaning will be required following water infiltration. Even with quick response actions, the area will have to be dried out and surfaces wiped down to prevent mold growth. If mold is visible, it must be completely removed. This can be as simple as washing and high efficiency particulate air (HEPA) vacuuming or as complex as demolition and reconstruction.
   (2) Successful cleaning requires an understanding of the location of contamination and the reason why fungal growth initially occurred. The more extensive the moisture damage, the more likely it is that you need to look for hidden mold colonization. Thus, it may be necessary to open and inspect representative structural components (i.e., destructive investigation) to estimate the extent of mold growth and determine the best remediation approach.
   (3) When writing or reviewing a cleaning and remediation plan, think about the following issues. While the plan should be written by the facility, public works or the contractor, it should be coordinated with and reviewed by IH, safety, occupational medicine (OM) and other appropriate members of the investigative team.
      (a) Type of Occupant. Use more conservative guidelines for cleaning mold in high risk populations, such as health care facilities or child care centers.
      (b) Building Structure. Residential buildings generally have more wood (framing) than commercial buildings. Commercial building may have steel support structures that are less likely to support mold growth and are usually easier to clean if they become contaminated.
      (c) Building Use. Special protocols are needed to clean mold in libraries or museums where discarding contaminated contents may not be an option.
      (d) Extent of Contamination. Small areas of visible mold growth can be cleaned quickly and easily. At the other extreme, buildings with extensive contamination may need to be demolished down to the structural framing for successful remediation.
      (e) Potential Health Effects. Are occupants reporting mold related symptoms? Are there confirmed diagnoses from a physician (vs. self-reported diagnosis)?
      (f) Potential for Personnel Exposure. Define the exposure pathway to ensure remediation addressees the complete process.
      (g) Remediation Risks. Consider the potential for spreading contamination and possible health impacts to occupants and remediators.

(h) Remediation Costs. Can the area be cleaned successfully? What are the costs for remediation vs. relocating employees to another site?

(i) Building Plans. Is the contaminated building already scheduled for demolition or extensive renovation?

b. Cleaning Guide Based on Type of Material. In general, the success and ease of cleaning building materials is based on their porosity.

(1) Non-Porous. Materials that do not absorb moisture and will dry quickly, such as metal, glass, hard plastic, tile. These materials can usually be salvaged by thoroughly cleaning with a mild detergent solution. If visibly contaminated, materials should also be HEPA vacuumed before returning to service. Ensure that ALL surfaces of the object(s) are clean.

(2) Semi-Porous. Materials like wood, concrete, linoleum and vinyl floor covering, vinyl wall covering, hardboard furniture, painted drywall or plaster. These will absorb moisture if exposed to water for a long time. Generally, if semi-porous materials are wet, it is best to discard them. However, if they are structurally sound and only minimally wet or have only a small area of mold growth, they can be dried thoroughly and cleaned the same as non-porous materials. Drywall/plaster should be removed or cleaned at least six inches beyond any water damage, or visible mold growth, including hidden mold reservoirs.

(3) Porous. Because porous materials readily absorb and retain water, they should almost always be discarded. Examples include carpet, padding, mattresses, stuffed furniture, wicker, fabrics, wallboard, insulation and ceiling tiles. You can usually save linens, drapes and clothes after thorough washing or professional dry-cleaning.

(a) Damp wiping and vacuuming will not work because you cannot clean the air spaces and channels that are an inherent part of the structure of porous materials. For example, damp wiping gypsum wall board will remove vegetative colonies and mold components on the surface but will not remove colonies or spores that have infiltrated the “nooks and crannies” within and throughout the wallboard. This is why if you wash mold off a wall but take no further action, the mold will usually reappear in a week or so.

(b) The exception to discarding porous materials is when dealing with items that have historic or high monetary value, are irreplaceable, or have sentimental or other inherent value (i.e., certain furniture, books, art, rugs). Such articles may be cleaned, but it requires special procedures and hiring a specialist is usually the best option. This is very expensive and may not be successful.

(4) Following is general guidance for cleaning groups of materials that are damaged by clean water and/or have visible mold growth. Check material dryness with a moisture meter. For floors and structural components, a meter with drivable pins is best so that the probes can penetrate to the center of the material.

(a) Papers and Books. For non-valuable items, discard. Consider photocopying important documents and discarding the originals. You may be able to freeze or freeze dry paper items. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed

double plastic bags. If discarding material, seal in double plastic bags and dispose of as normal waste. HEPA vacuum area after it is dried.

(b) Ceiling Tiles & Insulation. Discard. Also, seal in double plastic bags. Dispose of as normal waste. HEPA vacuum area after it is dried.

(c) Upholstery & Drapes, Including Upholstered Furniture. Use wet vacuum. May require fans, heaters and dehumidifiers for complete drying. Launder drapes if washable. If foam or stuffing material in upholstered items cannot be dried completely, remove and replace it. If this is not possible, discard the item. If the piece is valuable, you may wish to consult with a restoration professional, specializing in water damaged furniture. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed double plastic bags. If discarding material, seal in double plastic bags and dispose of as normal waste. HEPA vacuum area after it is dried.

(d) Wallboard, Drywall, Gypsum. If wet/water damaged or more than a small area of mold growth, discard. If only minimally wet/water damaged or only small area of mold growth, may be cleaned and dried in place and checked with moisture meter. Remove or clean at least six inches beyond any water damage or visible mold growth, including hidden mold reservoirs. Ventilate wall cavities to ensure drying of support structures. If seams separate or swelling occurs, remove and discard. If visible mold growth reoccurs, remove and discard. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed double plastic bags. If discarding material, seal in double plastic bags and dispose of as normal waste. HEPA vacuum area after it is dried.

(e) Wood Surfaces (such as floors, furniture, wood structure supports). Use wet vacuum. Treated or finished wood surfaces may be cleaned with mild detergent and clean water or wood cleaner/wood floor cleaner, scrubbing if necessary. Dry furniture or flooring thoroughly. May require fans, heaters and dehumidifiers for complete drying. Use heat with caution so as not to split or crack the wood. Wood paneling should be removed from the wall for drying. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed double plastic bags. If discarding material, seal in double plastic bags and dispose of as normal waste. HEPA vacuum area after it is dried.

(f) Hard Surfaces & Non-Porous or Semi-Porous Flooring (metal, plastic, glass, linoleum, vinyl, ceramic tile). Wet vacuum/damp wipe hard surfaces with water and mild detergent and allow to dry, scrubbing if necessary. Mop non-porous or semi-porous flooring with mild detergent, scrubbing if necessary, or wet vacuum excess water. Then, air or heat dry. It is important to check subfloors with a moisture meter to ensure they are dry. Dry underflooring, if necessary. If drying is not successful or flooring warps, cracks or splits, it will be necessary to remove the floor completely. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed double plastic

bags. If discarding material, seal in double plastic bags and dispose of as normal waste. HEPA vacuum area after it is dried.

(g) Carpet and Backing/Padding. While carpet can be successfully cleaned and dried if done correctly and within 24-48 hours after subjected to water intrusion, in most cases it is more economical and practical to remove and discard the carpet and pad. Individual rugs can be washed or dry-cleaned. If attempting to clean carpets, use a wet vacuum, dehumidifiers and fans. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed double plastic bags. If discarding material, seal in double plastic bags and dispose of as normal waste. HEPA vacuum area after it is dried.

(h) Concrete and Cinder Block. Use wet vacuum. Dehumidifiers, fans and/or heaters will probably be needed for thorough drying. Also, HEPA vacuum after the material has been thoroughly dried. Dispose of the contents of the HEPA vacuum in well-sealed double plastic bags.

c. Cleaning Guide Based on Cleaning Method

(1) Wet Vacuuming, also called Water Extraction Vacuuming. Used to remove water from floors, carpets, hard surfaces, upholstered furniture, concrete, cinder block or wood surfaces. For porous materials that have been wet less than 48 hours and are not visibly contaminated, these vacuums can be useful to speed the drying process. DO NOT use wet vacuums on porous materials after they are dry, as this can actually spread spores. Thoroughly clean and rinse the vacuum, hoses and attachments after use.

(2) Damp Wiping. For visibly contaminated hard, non-porous surfaces (metal, glass, hard plastic, tile) and some semi-porous surfaces (wood, linoleum and vinyl floor covering, vinyl wall covering, hardboard furniture, minimally damaged painted drywall or plaster), mold spores and fragments can usually be removed satisfactorily by wiping the surface and/or scrubbing with water and a mild detergent solution. Use wood cleaner or wood floor cleaner for wood surfaces to preclude further damage to the wood. Ensure that all wiped surfaces are completely dried.

(3) HEPA Vacuuming. Vacuum all materials and surfaces in the remediation area, once cleaned and dried, with a HEPA vacuum.

(a) Ensure materials are completely dry before vacuuming. Properly cleaned and vacuumed items can usually be returned to service when the area is cleared for re-occupancy.

(b) HEPA vacuum any settled dust on room surfaces outside the remediation area.

(c) HEPA vacuum all room surfaces before collecting any clearance samples, making sure to vacuum ledges, cabinet tops and other hidden surfaces where spores are likely to settle.

(d) The HEPA vacuum filter and contents should be double bagged, sealed and disposed of properly.

(4) Disposal. Prior to disposal, secure mold-contaminated waste using the following procedures. Ensure that rags, disposable protective clothing and similar items are also placed into disposal bags. Dispose of wastes in a sanitary landfill.

(a) Small/Medium Remediation Jobs (i.e., <100 square feet (ft^2) or <10 ft^2 in an HVAC system). Lightly mist contaminated materials that are being discarded BEFORE disturbing the material. Use a handheld sprayer filled with water or a water/ mild detergent mixture. Misting will minimize generating airborne mold or dust during handling. Double bag materials using 6-millimeter thick polyethylene (6-mil poly) bags, seal and damp wipe the outside of the bag before disposal (usually as regular construction waste).

(b) Large Remediation Jobs (>100 ft^2 or >10 ft^2 in a HVAC system). Lightly mist contaminated materials that are being discarded BEFORE disturbing the material. Use a handheld sprayer filled with water or a water/mild detergent mixture. Misting will minimize generating airborne mold or dust during handling. Use double 6-mil poly bags or sheeting for discarding contaminated items and construction debris. While inside the containment area, place item(s) being discarded into a bag or onto a sheet. Secure bags with a twist tie or equivalent. Secure sheeting by folding the sheet around the item and taping. Transport bags/sheeting for disposal to the decontamination area. Damp wipe outside of bags or sheeting. Place wiped bag or sheet into second bag/sheet and secure. Damp wipe the outside of the second layer of polyethylene. HEPA vacuum outside of bag/sheeting.

d. Antimicrobial Products (Biocides & Sanitizers)

(1) In general, antimicrobial or biocide solutions are not recommended for most cleanups. While the correct selection and use of these products may be needed in some situations (i.e., if immunocompromised personnel are involved or to eliminate pathogens from gray/black water contamination), the preferred procedure is to remove the mold. Though the biocides will kill the mold, the remaining dead biomass can be allergenic and toxigenic.

(2) Since most antimicrobials are irritants, improper application can actually cause additional problems when the area is reoccupied. If biocides are required, prepare and apply according to manufacturer directions, ensure adequate contact time and ventilate the area. Sample antimicrobial agents are listed in Appendix 13.3-A.

(3) Antimicrobial pesticides are used to:

(a) Disinfect, sanitize, reduce or mitigate growth or development of microbiological organisms.

(b) Protect inanimate objects, industrial processes or systems, surfaces, water or other chemical substances (e.g., paints, metalworking fluids) from contamination, fouling or deterioration caused by bacteria, viruses, fungi, protozoa, algae or slime.

(4) The EPA regulates antimicrobial agents used on inanimate objects and surfaces as pesticides. More than 5000 antimicrobial products are currently registered with EPA. Ensure that only registered products are used and that those applying pesticides are trained and certified as appropriate for the product used. Go to the EPA website for more information.

NOTE: that the EPA does not "approve" biocides for mold remediation applications. Beware of remediation companies making such claims. Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), the EPA has regulatory authority over pesticides and antimicrobial products but supporting legislation to review specific product applications and issue "approvals" was never adopted or funded.

(5) The EPA cautions against using disinfectants and sanitizers in ventilation systems. In Reference 13.3-5 (letter and supplement), the EPA states that many of these products have not been evaluated for exposure risks to building occupants or applicators. Consequently, disinfectants and sanitizers should not be used in HVAC systems unless the product contains directions specific to HVAC systems application on the label. Additionally, for a product to have HVAC system use on the label, the product needs to have had a risk assessment conducted by the EPA and the product registered for that use with the EPA.

(6) "Gassing" the building (i.e., using gaseous chlorine dioxide or ozone) is not recommended. There is insufficient data on the efficacy of such wholesale sanitizing. Further, the chemicals themselves are toxic and may cause harm if used inappropriately.

4. Protection During Remediation

a. Protecting Remediation Personnel. Anyone performing actions that are likely to disturb or dislodge mold should wear personal protective equipment (PPE) to prevent inhalation of and direct contact with mold. Ensure that personnel are instructed on proper donning and doffing techniques and are enrolled in the appropriate medical surveillance programs.

(1) Gloves. Use gloves to protect against contact with mold biomass (allergens), toxins and/or cleaning solutions that may irritate the skin. Rubber household gloves are adequate for contact with mold-contaminated materials. If using biocides or strong cleaners, select the glove material appropriate for the chemical (usually nitrile, neoprene, PVC or rubber will be sufficient).

(2) Eye protection. Wear a minimum of tight-fitting, unvented goggles to prevent irritation from particulates. (If a full-face respirator is worn, that is also sufficient.)

(3) Respirators. Respiratory protection prevents inhaling the airborne mold, spores and particulates that will be in the remediation area. All personnel wearing a respirator must be trained, fit tested and enrolled in the Respiratory Protection Program (RPP). Wear only respirators approved by the NIOSH.

(a) The following recommendations are based on References 13.3-1 and 13.3-2.

1. Use a N95 air-purifying respirator, as a minimum, for small area remediation (<10 ft^2 or <10 ft^2 in a HVAC system).
2. If the job involves more than 10 ft^2 but less than about 100 ft^2 of contaminated material, use, as a minimum, a N95 air-purifying respirator. A half or full face (tight fitting) air- purifying respirator with P100 filters may be used based on site-specific conditions.

3. If the job involves more than 10 ft^2 in a HVAC system, use, as a minimum, a half face (tight fitting) air- purifying respirator with P100 filters.
4. If remediating an extensive contaminated area (>100 ft^2) or an area with high concentrations of mold, use, as a minimum, a full-face (tight fitting) air purifying respirator with P100 filters. Preferably use a full-face powered air purifying respirator (PAPR) with P100 filters, based on site-specific conditions.

(4) Coveralls, Head and Foot Coverings. Disposable coveralls keep molds and spores from contaminating personal clothing. Coverings also prevent direct skin contact with the mold biomass. Therefore, disposable coveralls are suggested for small area (<10 ft^2) remediation. However, as a minimum, wear disposable coveralls for remediation of more than 10 ft^2. For large remediation (>100 ft^2 or >10 ft^2 in a HVAC system), wear mold/dust impervious coveralls and ensure all openings (i.e., zipper, wrists, leg) are taped and head and foot coverings are also worn.

(5) Other references may cite different recommendations for protective procedures and equipment.

(a) Reference 13.3-4 cites that "a microbial remediation plan shall consider Table 17.1 in AIHA IMOM08-679, *Recognition, Evaluation and Control of Indoor Mold*, which lists the minimum levels of respiratory protection based on the activity and size of the remediated area." However, the PPE recommendations referred to in this AIHA book are generally equivalent to the above recommendations, though disposable coveralls are recommended for small area remediation and disposable dust impervious coveralls for medium area remediation. However, in the case of eye protection, these AIHA book recommendations are less protective than the above recommendations.

b. Protecting Occupants.

(1) Scheduling Remediation. Consider scheduling remediation work during minimum occupancy hours to incur the least disruption.

(2) Relocation. In most cases, it is not necessary to vacate the building during remediation as long as the work area is properly controlled. However, occupants in the actual work site should be relocated until remediation is complete. During large remediation, offices adjacent to the enclosure should be vacated to remove occupants from the noise, construction traffic and disruption associated with the work.

(a) If contamination results from gray or black water, especially in sewage situations, occupants should be removed from the building until cleanup and disinfection are complete.

(b) Work with the local OM department to determine if occupants with health problems should be relocated until cleaning/ remediation is complete and the building is cleared for re-occupancy. Health care providers may recommend temporary relocation based on individual medical evaluations. For example, people with hypersensitivity pneumonitis, severe allergies, asthma, immune suppression or chronic inflammatory lung diseases are at higher risk and may

require relocation or other accommodations during remediation. Chapter 13 Section 4 discusses medical evaluations specific to mold contamination events.

c. Protecting the Environment.

(1) Containments (enclosures) are used to prevent the release of mold, mold spores and remediation debris into the surrounding building areas and into the environment. Although the remediation procedures are loosely associated with the size of the contamination area, you have to consider actual mold concentrations. Small contaminated areas do not usually need to be enclosed before removal. If an area is heavily contaminated (i.e., "covered" with mold), there is a high potential for mold/spore release and subsequent spread of contamination to other areas. In this situation, an enclosure would be appropriate.

(2) Table 13.3-1 provides minimum containment procedures. Any remediation with high concentrations of mold and/or extensive contamination areas should institute the strictest containment procedures. Also, consider more extensive containments if demolition actions (i.e., cutting, hammering) are required to remove contaminated material. If removal work is contracted, acceptable containment requirements should be specified in the contract.

(3) When containments are properly constructed, the polyethylene sheeting will billow inwards when placed under negative pressure. If the sheeting billows outward or flutters, the containment is not properly sealed. Stop work until the containment is restored to full negative pressure.

Table 13.3-1
Mold remediation containment guide.

Procedure or Action	Contaminated Area, ft^2			HVAC[1]
	< 10	10-100	>100	
Remove occupants from work area[2].	✓	✓	✓	✓
Remove occupants from adjacent areas[2].			✓	✓
No containment needed.	✓			
Seal off work area with flame-retardant 6-mil polyethylene sheeting (i.e., critical barrier)[3]. Seal seams.		✓	✓ double poly	✓
Seal off all supply and return air ducts and doors into/out of the contained area.		✓	✓	

Procedure or Action	Contaminated Area, ft^2			HVAC[1]
	< 10	10-100	>100	
Secure ventilation system.		if needed to properly seal vents	✓	✓
Place work area under negative pressure using exhaust fan(s) equipped with HEPA filters. Exhaust air outside.		✓	✓	✓[4]
Use airlocks into/out of the work area.			✓	✓[4]
Establish decontamination room outside of the enclosure.			✓	✓[4]
Use dust suppression methods (misting) on any material or object to be removed, cut or discarded.	✓	✓	✓	✓
Dispose of contaminated material and cleaning rags per disposal guidelines.	✓	✓	✓	✓
Mop or wipe down area after cleaning/removal is complete.	✓	✓	✓	✓
After damp wiping, clean the same area with a HEPA-filtered vacuum	✓	✓	✓	✓
Visually inspect work area for cleanliness (no dust).	✓	✓	✓	✓
Conduct clearance sampling before removing containment.			✓	✓

[1] HVAC = heating, ventilation and air-conditioning system.
[2] Consult OM physician. Some occupants may be removed based on medical conditions such as recent surgery, chronic lung disease, immunosuppression, etc.
[3] Cover area with poly sheeting from ceiling to floor. Tape (or otherwise attach) poly to the framing or room perimeter. Tape all seams shut. Provide slit entry with covering flap. Maintain high negative pressure using HEPA filtered fan. Block supply and return vents in the contaminated area.
[4] If contaminated area is >10 ft^2.

5. The Mold Remediation Wheel

a. The Mold Remediation Wheel consolidates the guidance discussed in this section and provides remediation procedures, protection recommendations and engineering controls in a single page. The guidance is based on total contaminated area simply as a way of delineating job complexity. There is no known correlation between total contaminated area and occupant health effects. A movable Mold Remediation Wheel can be viewed, saved, printed and assembled from the links below.
   (1) Mold Remediation Wheel – outer panels.
   (2) Mold Remediation Wheel – informational insert.
   (3) The Mold Remediation Wheel is adapted from Reference 13.3-6, which is based on the Reference 13.3-2 EPA guidance. The Mold Remediation Wheel has been further modified to incorporate additional guidance and best practices from References 13.3-1 and 13.3-2.

b. The Mold Remediation Wheel is intended to be a quick reference tool for planning mold remediation actions based on the type of material that has been water damaged and/or contaminated. As with any tool where information is grouped into broad categories, refer to the chapter text and references for complete discussion.

c. How to use the Mold Remediation Wheel. Starting in the center, choose the type of material that has been damaged. Stay within the quadrant for the selected material and move outward toward the circle periphery. New conditions, choices or information are added with each new ring.
   (1) Center – START
   (2) 1st ring (white) = SELECT TYPE OF MATERIAL
   (3) 2nd ring (gold) = ACTION 24-48 HOURS - If response is within 48 hours of clean water damage and there is no visible mold growth, match the numbers in this ring with the response actions in the yellow box below the wheel.
   (4) 3rd ring (white) = ACTION >48 HOURS – If response is more than 48 hours after clean water damage or if there is visible mold growth, move to the 4th ring.
   (5) 4th ring (white) = CONTAMINATION AREA - Determine the extent of contamination. The general categories are:
      (a) Less than 10 square feet [<10 ft^2] (e.g., a ceiling tiles; small area of wallboard)
      (b) Between 10 ft^2 and 100 ft^2 [10 –100 ft^2] (e.g., 1-3 wallboard panels)
      (c) More than 100 ft^2 [>100 ft^2] (e.g., the whole wall)
   (6) 5th ring (blue) = CLEANUP / REMEDIATION METHODS - Match the letters in this ring with the remediation/ cleanup methods shown in the blue box below the wheel.
   (7) 6th ring (pink) = PPE – Match the letters with the personal protective equipment (PPE) codes in the pink box below the wheel.
   (8) 7th ring (green) = CONTAINMENT - In the outer ring, determine if containment is needed and if so, what level. Match the letter in this ring with the containment code in the green box below the wheel.

6. Qualified Personnel

There are no specific regulations that govern mold remediation or define qualifications for personnel who clean and remediate contaminated areas. Various references may cite different recommendations for trained/qualified personnel.

a. According to the Reference 13.1:
   (1) Small and Medium Isolated Areas (<100 ft^2; e.g., 3 sheets of wallboard). Remediation can be done by maintenance personnel who have been specifically trained on mold contamination cleaning procedures, potential hazards and proper protective equipment.
   (2) Small Areas in HVACs Systems (<10 ft^2). Remediation can be done by maintenance personnel who have been specifically trained on mold contamination cleaning procedures, potential hazards and proper protective equipment and who are familiar with the design and function of the impacted HVAC system.
   (3) Large Areas (>100 ft^2; e.g., an entire wall in an office) and Large Areas in HVAC systems (>10 ft^2). Only personnel specially trained in mold contamination cleanup and disposal procedures should do large scale remediation. Further, an occupational safety and health professional should oversee the remediation, including reviewing protocols and contract requirements.

b. References 13.3-3 and 13.3-4 list specific training/certification guidelines for microbial assessors, mold remediation supervisors, ventilation system mold remediators, IH and other workers.

7. Mold/ Indoor Air Quality Certifications

a. There are certifications that cover the range from indoor air quality generalist to very specific titles. Below are the sponsoring organizations and certifications they offer. We have listed only organizations whose certification requirements include as a minimum: education and/or experience to qualify; written examination; and ongoing training and recertification programs. This list is provided as an information resource to assist Navy IHs in making an informed decision about qualifications for mold remediators'. This listing does not imply endorsement by the Department of Defense (DoD), the Navy or NMCPHC, nor does it mean that these certifications have merit.
   (1) American Council for Accredited Certification.
      (a) Council Certified Indoor Environmental Consultant (CIEC™)
      (b) Council Certified Indoor Environmentalist (CIE™)
      (c) Council Certified Indoor Environmental Supervisor (CIES™)
      (d) Council Certified Indoor Environmental Remediator (CIER™)
      (e) Council Certified Microbial Consultant (CMC™)
      (f) Council Certified Microbial Investigator (CMI™)
      (g) Council Certified Microbial Remediation Supervisor (CMRS™)
      (h) Council Certified Microbial Remediator (CMR™)

(i) Council Certified Moisture Control Consultant (CMCC™)
(j) Council Certified Moisture Control Investigator (CMCI™)
(k) Council Certified Structural Drying Supervisor (CSDS™)
(l) Council Certified Structural Drying Remediator (CSDR™)
(m) Council Certified Indoor Air Quality Manager (CIAQM™)
(n) Others (http://www.acac.org).

(2) Institute of Professional Environmental Practice.
(a) Qualified Environmental Professional (QEP)
(b) Environmental Professional Intern (EPI)

(3) National Air Duct Cleaners Association.
(a) Certified Air Systems Cleaning Specialist (ASCS)/Ventilation System Mold Remediator (VSMR)
(b) Certified Ventilation Inspectors (CVI)

8. Post-Remediation

a. After remediation, the site's underlying moisture problems should be fixed; the site should be dry, clean and free of visible mold growth or moldy odors and free from visible dust and debris. Also, when revisiting the site shortly after remediation, no signs of water damage, mold growth or moldy odors should have reoccurred. People should be able to occupy or re-occupy the space without mold related health complaints or physical symptoms.

b. If any sampling is performed, only background types and concentrations of mold, similar to those found outside, should remain.

9. Post-Remediation/Clearance Sampling

a. General Considerations.
(1) References 13.3-1, 13.3-2 and 13.3-7 provide guidance on assessing and remediating fungal contamination in buildings. Though there are differences in the documents, they all agree that visible fungal growth should not be present in indoor occupied space, regardless of the number or type of fungi. Consequently, the goals of remediation are to completely remove microbial reservoirs and to thoroughly clean the air and all surfaces in the affected area.
(2) The Centers for Disease Control (CDC), EPA, New York City Department of Health, and the UFGS guidance for mold remediation do not recommend routine sampling for molds.
(3) According to the EPA Mold Course, air sampling for mold or other biological contaminants usually is not necessary to determine remediation effectiveness. They go on to mention that such clearance sampling may be less effective at determining the success of remediation than visual inspection of the area.
(4) Reference 13.3-4 lists specific information on clearance procedures, sampling and criteria in circumstances where clearance sampling is performed. Reference 13.3-4

only requires clearance sampling for remediation projects in buildings that will be occupied by sensitive and/or high risk populations, such as hospitals, child care centers, certain treatment centers or when specified by the local medical support staff.

(5) Before performing any type of mold sampling, in any building, be sure there is a clear plan for data evaluation. Understand the sampling limitations and what the results may – or may not – mean.

(6) Always have any samples analyzed by a laboratory accredited by the AIHA under the Environmental Microbiology Laboratory Accreditation Program (EMLAP), and proficient in the Environmental Microbiology Proficiency Analytical Testing (EMPAT) program for the specific field of testing methods used.

b. Clearance Sampling Considerations (if clearance sampling is performed).

(1) Clearance sampling is not always needed, especially for small remediation jobs.

(2) General area, HVAC system and/or surface sampling, performed both before and after cleaning, may be useful to show remediation success. Sampling should only be performed after developing a sampling plan that explains where and how to sample, pass-fail criteria, and what action is required if samples fail.

(3) Clearance sampling should be considered when:

(a) Litigation is involved

(b) Specific health concerns are a problem

(c) Sensitive populations are involved

(d) Must assure personnel that mold was successfully removed

(e) Must document that the containment was not compromised

(f) Must show that a remediated area is ready for occupancy (particularly by sensitive populations)

(g) If more than 10 ft^2 of the HVAC system has been remediated.

1. After the ventilation system is cleaned and visually inspected, sample in the ducts, at the supply registers, and/or in the ambient spaces served by the remediated system to make sure the ducts are clean and adjacent spaces are not contaminated.

(4) Remember that the area will not be sterile even after a successful remediation. In general, you are looking for a decrease in the number and types of fungi.

(5) After remediation, the kinds and concentrations of mold and mold spores in the building should be similar to those found outside.

c. Clearance Sampling Procedure (See Figure 13.3 for process diagram).

(1) Perform a visual inspection of the cleaned, remediated area to ensure absence of visible fungal growth. It may be helpful to do a “white glove inspection” – that is, use a clean white glove, sterile cotton gauze square or equivalent. (A clean cloth of another color, suitable to reveal expected type of dust, may be used, particularly if a white or light colored dust is expected.) Wipe across surfaces to check for dust or debris. This is particularly helpful for quickly checking ledges, recessed surfaces and out-of-the-way areas. Carefully inspect hard to reach spots since they may have been missed or insufficiently cleaned during remediation.

(2) Any areas or surfaces that do not pass the visual inspection must be re-cleaned (i.e., damp wiped with water/detergent, then HEPA vacuumed).
(3) If the remediated area includes a containment, conduct any clearance sampling with the containment in place. Leave negative air systems running so any remaining contamination will not be distributed.
(4) Collect air samples inside the work area using aggressive techniques (i.e., use a leaf blower to move the air in the room before sampling). Total spore counts are sufficient for clearance sampling except in very unusual cases.
(5) Collect air samples outside, preferably at the fresh air intake that supplies the remediated area, to use as ambient controls for comparing with inside results.
(6) You may want to collect control samples in non-contaminated areas of the building that can be used for comparing the inside contaminated/remediated site with a comparable inside non-contaminated/non-complaint area.
(7) Swab or tape samples are usually sufficient to check for adequate surface cleaning.

d. Interpreting Clearance Sample Results.
(1) Inside sample results should be less than or equal to outside sample results for total spores, rank order and biodiversity of taxa.
(2) In pre- and post-remediation sampling comparisons, as a minimum, post-cleaning results should be significantly less than pre, with no indicator species present above background levels.
(3) Indicator species (Aspergillus, Penicillium, Chaetomium, Stachybotrys, Memnoniella) in inside samples should be absent or lower than outside control samples.
(a) For practical purposes, finding 1 or 2 spores of an indicator species inside during clearance sampling should not automatically trigger re-cleaning. However, because the mere presence of some indicator species, like Stachybotrys, may cause employee concern, it may be prudent to repeat the cleaning protocol until no spores are found during clearance sampling if feasible. The investigating team should determine whether zero indicator species spores would be required to pass the clearance test. Document the decision in the sampling plan along with the criteria for clearance.
(4) If indoor total spore concentrations are greater than outdoor results, or if there are reversals/differences in rank order and biodiversity, this indicates that fungal reservoirs may still be present in the work area. Inspect the area for visible contamination. If mold is found, repeat the remediation protocol for the affected area and contents. If unable to locate visible contamination, search for hidden mold reservoirs and, if found, repeat the complete protocol.
(5) In general, if inside sample results are less than or equal to outside results (total spores, rank order, biodiversity of taxa and indicator species), the area can be reoccupied. Actual re-occupancy criteria will be specified in the remediation plan.
(6) Medical Support Sampling. In cases with medical diagnoses that indicate suspected or specific fungi, clearance sampling should include viable sample collection so that recovered fungi can be speciated.

(a) If diagnosis is linked to allergic symptoms, total spore counts are essential for clearance sampling because analysis counts all particulates. Remember that dead mold spores can still elicit allergenic responses.
(b) If a genetic signature (target specific primer) is available for a suspected causative fungus, polymerase chain reaction (PCR) testing may also be useful.

e. Other Possible Post-Remediation Tests.
(1) Carpet. If carpet was cleaned rather than removed, clearance sampling should include collecting representative samples with a micro-vacuum on a 1 ft. x 1 ft. template. Sample results should show spore counts, rank order and biodiversity less than pre-cleaned carpet samples.
(a) Remember that it is almost always best to remove and discard water-damaged carpet. Carpet damaged from clean water may be successfully cleaned if it is properly dried within 24-48 hours and has no visible growth. For gray water damage, salvaging carpet will depend on the extent of damage and the responder's professional judgment. Without exception, discard carpet damaged by black water.
(2) Surface Cleaning Effectiveness. If you need to confirm surface cleaning effectiveness for decontamination of non-porous or semi-porous materials, collect surface samples using tape, swabs or wipes. Surface sampling results should be at background levels.
(3) Moisture Testing. Moisture meters can be useful to monitor the drying process for wood (e.g., flooring, structural supports, siding), concrete, brick, carpet, wallboard and EIFS.

10. After the Remediation: Ensuring Success

a. Follow-up inspections are required to ensure that contamination conditions do not recur. Re-inspect the remediated area every 2-3 weeks until satisfied that water intrusion has stopped and mold growth is unlikely to recur. Look for any new water sources or water damage. Also check to ensure that porous/semi-porous building materials that were cleaned remain free of visible contamination.

b. Provide update reports to employees/occupants until the investigation team determines that the contamination has been successfully remediated. Provide a final report to occupants when remediation is complete.

c. Ensure there is an appropriate preventive maintenance plan for the HVAC system and that the building owner understands the importance of strict maintenance.

11. References

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Section Four – Mold Investigation Medical Guidance

1. General

a. Buildings that have been water damaged for several days or more, whether from flood, leaking roofs or walls, broken plumbing, improperly installed or adjusted humidifiers, or condensation on cold surfaces, may become culture media for any of a number of molds and fungi.

b. Molds are thought to affect human health by any one or more of three mechanisms: infection (by exposure of a susceptible individual to mold spores, generally, but not always, a person who is immunocompromised), hypersensitivity (allergy to mold spores, components or toxins, including eczema, asthma and hypersensitivity pneumonitis) or direct irritation by mycotoxins (toxins produced by mold).

c. Results from a large indoor air study (Reference 13.4-1) found that:
   (1) Culturable airborne fungal concentrations in indoor air are lower than those in outdoor air.
   (2) Fungal concentrations are highest in the fall and summer and lowest in the winter and spring.
   (3) Geographically in the continental U.S., fungal concentrations are highest in the southwest, far west and southeast.
   (4) The most common culturable airborne fungi, both indoors and outdoors and in all seasons and regions, were Cladosporium, Penicillium, nonsporulating fungi and Aspergillus.

d. Considerable interest and controversy have been generated recently about searching for and identifying specific molds in buildings. The CDC's position is that determining what type of mold exists is unnecessary, and that all molds should be treated the same with respect to potential health risks and removal (Reference 13.4-2).

e. Mold may proliferate almost anywhere that has too much moisture. Even if renovation is done properly, recurrence of moist conditions may lead to mold regrowth. In one study, uninstalled wallboard available from local distributors was found to contain a baseline bioburden, including Stachybotrys chartarum. The authors noted that sanitation and preservation treatment of the wallboard can markedly delay regrowth of certain fungi, particularly of S. chartarum (Reference 13.4-3).

f. Mold has been considered (as of 2018) but has not been established as a causative agent of building-related illness (BRI). BRIs are caused by known pathogens, have specific symptoms and may be serious. Specific BRIs include those caused by Legionella species (Pontiac Fever, Legionnaire's Disease) and humidifier fever. Other airborne infectious diseases may have increased transmission when there is inadequate ventilation (e.g., Tuberculosis, Varicella and Q fever), References 13.4-4/9. Other symptoms from indoor air contamination of offices where workers shared ventilation contaminated with algal toxins (Pfiesteria piscicida, a dinoflagellate) are suspected to have occurred.

g. In April 2016, the European Association of the Scientific Medical Societies presented a guideline ("Medical Clinical Diagnostics of Indoor Mould Exposure"), Reference 13.4-10. An abridged version is also available, Reference 13.4-11. One of their conclusions was, "apart from allergic bronchopulmonary aspergillosis (ABPA) and mould-caused mycoses, only sufficient evidence for an association between moisture/mould damage and the following health effects has been established: allergic respiratory disease, asthma (manifestation, progression and exacerbation), allergic rhinitis, hypersensitivity pneumonitis (extrinsic allergic alveolitis) and increased likelihood of respiratory infections/bronchitis." Another conclusion was, "In the case of indoor moisture/mould damage, everyone can be affected by odour effects and/or mood disorders. However, this is not a health hazard." The guideline also states that the risk for developing asthma is increased in patients with allergic rhinoconjunctivitis, patients with allergic rhinosinusitis and atopic patients, and that "it is likely that all moulds are capable of causing sensitization and allergies. Their allergenic potential is considered lower compared with other environmental allergens."

h. Prudent health practice dictates limiting exposure of immunocompromised persons to excessive levels of mold spores and limiting exposure of sensitized (allergic) individuals to airborne or surface contamination of the specific mold to which the individual is sensitized.

2. The Physician's Role in the Investigation and Resolution of Mold-Related Problems

a. The medical member of the IEQ investigative team can contribute valuable expertise in advising what organisms the industrial hygienist should sample for, based on medical findings in one or more patients. If there is reason to suspect a particular species of mold—because of worker fungal infection or identification by a worker's health care provider (HCP) of allergy to a specific mold—IHs can be asked to direct sampling to recover and appropriately identify that organism. Requesting IH to "sample for molds" because of non-specific symptoms in workers is not helpful, since simply the presence of mold (which is ubiquitous) may be insignificant with respect to human health.

b. Communication between medical and other team members is important when trying to determine if there is an exposure pathway. For example, discovery of mold on surfaces may be incidental in a situation where airborne contamination is the problem (e.g., a non-mold organism such as Legionella).

c. Physicians should be alert to the state of building moisture when workers complain of mold-related complaints. Wherever there is moisture and a substrate, mold is likely to grow. Building managers may partially address water intrusion without removing contaminated wallboards or carpeting, and claim that the problem has been "solved." When necessary, building remediation, including surface decontamination (i.e., replacing rugs and wallboard and decontaminating solid surfaces such as concrete), eliminating water intrusion (especially roofs and windows), repairing plumbing leaks, etc., must be complete.

3. Evaluation of Workers with Possible Mold-Related Adverse Health Effects

a. Physicians caring for workers concerned about mold should resist pressure to order mold sampling of the work environment. Mold exists in virtually all environments, and without clinical correlation (such as a respiratory infection due to a specific mold), mold sampling will confirm the presence of mold, but the finding is not meaningful. The European Association of the Scientific Medical Societies guideline addresses which tests may or may not be helpful for the clinician caring for a patient exposed to mold, Reference 13.4-11.

b. A thorough medical history should include a history of exposures in the home, workplace and during leisure time, history of infections and predisposing factors, history of allergies and predisposing factors, history of irritant effects, history of the effects of odors and a history of mood disorders.

c. Physical exam should include particular attention to the lungs, upper respiratory tract, mucous membranes, affected skin (at least—and especially—exposed skin) and any other areas of concern.

d. If the medical history indicates mold allergy, skin testing and testing for specific serum immunoglobulins E (IgE) antibodies in type I sensitization are appropriate, as may be provocation testing. Although specific IgE indicates a specific sensitization, it does

necessarily indicate clinically relevant allergy. Conversely, negative skin and blood tests do not exclude sensitization to mold.

e. Additional studies should be done according to the findings of the initial evaluation, and should not be limited to evaluating only for mold-related illness.

4. Returning Workers to a Building under Investigation.

a. In general, it is preferable not to keep workers out of the work area, nor to advise workers to avoid returning to a building unless (1) a diagnosis of a BRI has been established, or (2) a building-related diagnosis is suspected based on symptoms, disease patterns and findings consistent with a BRI.

b. If a worker is confirmed to have building-related mold allergy or mold infection, the worker should not be allowed back into the building until remediation has been completed and reduced levels of mold are documented by post-remediation sampling. After remediation, re-exposure should be done with caution. It may be appropriate to have medical care immediately available in the case of serious allergic reactions. If remediation has been adequate, there is reason to expect the worker may successfully return to a building with few or no mold-related symptoms, Reference 13.4-12.

c. The etiology of a worker's condition may be unknown, but the worker's condition is serious enough (e.g., anaphylaxis) that further exposure to any potential offending agent represents an unacceptable health risk. In such cases, it is prudent to recommend against further exposure to a building until the medical workup is complete.

d. The HCP should perform a thorough and accurate workup as indicated by the symptoms, signs and findings of the patient, without focusing on mold. Specifically, the HCP should resist ordering tests that are not indicated by the medical workup.

e. The HCP should avoid labeling a building a "health hazard" or stating that mold in the building is the etiology of a person's symptoms until after the facts have clearly established such a link. A discussion of airborne microorganisms concluded, in harmony with the European Association of the Scientific Medical Societies, that "in general, mold growth in indoor spaces is a hygienic problem," rather than a health hazard, Reference 13.4-13. Incorrectly identifying building mold as the cause of adverse health effects can lead to undue anxiety and loss of income among workers, decreased productivity, increased operating costs and decreased readiness. It can also divert attention from identifying the actual cause of health complaints. Once a causal relationship has been established, however, relocation of affected workers to a different building may be appropriate.

f. Even in patients with no known allergy to mold, exposure to increased levels of mold can cause subjective eye symptoms and increased tear fluid C3a, Reference 13.4-14.

g. A case report of office-related *Alternaria* allergy supports the following as considerations for concluding an association exists between IEQ-related mold exposure and illness in an occupational setting: symptoms and signs consistent with a medical

diagnosis, either in vitro or in vivo evidence of exposure, environmental evidence of plausible biological exposure and substantial improvement or resolution of the illness after appropriate building remediation, Reference 13.4-15 (It is acknowledged that requiring remediation be successful in order to make a conclusion about causation is unsatisfactory. However, that is the limitation of the current science.).

5. Remediation

a. Successful remediation can result in a building that can be reoccupied without recurrent related illness, even in a subtropical climate, Reference 13.4-16. However, in individuals who develop severe non-respiratory symptoms and asthma, remediation may not result in improved health, Reference 13.4-17.

b. If sampling confirms the presence of pathogens suspected because of the symptoms, signs or findings exhibited by building occupants, remediation effectiveness should be confirmed by clearance sampling before building reoccupation. Building processes (for example, heating, ventilation, air conditioning and humidification systems or decorative fountains) that may be similar in other buildings may warrant preventive attention as a public health measure. Building engineers, inspectors or public health officials may be appropriate points of contact in such situations.

c. A 2018 review of allergen reduction practices and asthma management found that single interventions (e.g., using HEPA vacuum cleaners or removing carpets) did not significantly improve asthma outcomes, whereas multi-component interventions did, Reference 13.4-18.

6. Infections Due to Mold

Molds are usually opportunistic pathogens, causing clinically significant infections in cases of overwhelming exposure or in individuals who are immune-compromised (i.e., debilitated by extremes of age, underlying infection, poor sanitation, inadequate nutrition, wounds), immune suppressed (chemotherapy, severe stress, pregnancy) or immune deficient (human immunodeficiency virus). A notable exception is the outbreak of *Cryptococcus gattii* originating in Vancouver Island, British Columbia, Canada, which infected apparently healthy adults, most likely from outdoor sources, Reference 13.4-19. Mold infection diagnoses will be made by appropriate microbial identification studies or clinical courses (which are beyond the scope of this document).

7. Allergies and Allergens.

a. Allergens are common in most environments. Certain classes of allergens are especially pertinent to an indoor environmental quality investigation. The history given by those affected can be the most helpful information in determining the source of the problem.

b. Skin (allergic contact dermatitis) or respiratory (including asthma) allergy symptoms are the most likely symptoms encountered from building-related mold allergy. Sensitivity to

mold allergens is an important risk factor for adenoid hypertrophy in children with allergic rhinitis, Reference 13.4-20. Adult-onset asthma is associated with self-reported mold exposures in the home, Reference 13.4-21. Some authors claim that approximately 20% of asthma cases are related to "dampness and mold" indoors, Reference 13.4-22. While other studies have failed to find a correlation between indoor moldy odor and mold spore concentration, and between mold spore concentration and asthma in children, Reference 13.4-23. A 2018 review article only found three studies that examined quantified building moisture and occupant health effects; two of those found a correlation between moisture and asthma incidence, and one found a correlation between moisture and atopic dermatitis, Reference 13.4-24. Other organ system involvement, such as gastrointestinal hypersensitivity-related complaints, may be a clue that the offending exposure may not be related to the indoor environment but to an ingested allergen.

c. Specific IEQ-associated illnesses with an allergic (sensitization) basis include asthma, hypersensitivity pneumonitis, rhinitis or sinusitis, bronchitis or tracheitis (usually associated with sinusitis), and humidifier fever (HF). HF is thought to be allergic, as patients have shown sensitivity and symptoms with exposure to specific antigens in humidifiers, Reference 13.4-25. HF has been associated with contamination of humidifiers by biologicals including amoeba, fungi, *Bacillus subtilis*, endotoxins, flavobacterium and *Pseudomonas* species (References 13.4-26 and 13.4-31). It is also possible that not all etiologies of IEQ-related allergic complaints are biologicals, as one report noted heating, ventilation and air conditioning system "dust and mud," Reference 13.4-32.

d. Spirometry may help document involvement of the lower respiratory tract. A peak flow meter may be the simplest way to document expiratory impairment or exacerbation of asthma with building exposure, Reference 13.4-33. A significant association was found between basophil histamine release showing serum IgE specific to one or more indoor molds, and building-related symptoms in individuals working in damp and moldy buildings, Reference 13.4-34. Skin testing (skin prick test) may be more sensitive than blood testing (radioallergosorbent test, commonly called RAST) in detecting sensitization to molds. However, determining a specific mold to which someone is allergic in a given situation may be difficult, as sensitized individuals often react to more than one species, Reference 13.4-35.

8. Irritation

a. *Stachybotrys* mycotoxins are biologically active, Reference 13.4-36, and it is thought that they act as irritants. Respiratory irritation has been documented to occur in rodents exposed to *Stachybotrys,* Reference 13.4-37. Special conditions may be necessary for mycotoxins produced by surface *Stachybotrys* in a building to reach sufficient concentrations to cause such effects, according to the results of one experimental study, Reference 13.4-38. There has been controversy as to whether direct irritation from mycotoxins, rather than a hypersensitivity-related response to molds or

mycotoxins, has occurred in humans exposed to mold in indoor air. (For a mycotoxin to cause health effects, it must be ingested, absorbed or inhaled; unless a mycotoxin is volatile, inhalation is not likely.)

b. The primary indicator that symptoms among workers may be caused by building-related mold is that there is a temporal relationship of the symptoms to building exposure. Mold allergy may involve both IgG and IgE immunoglobulins, Reference 13.4-39. Thus, an allergic reaction may occur immediately on entering a building, after several hours of exposure or even 2 to 8 hours after leaving the building. A clear worker history of a temporal association of allergy symptoms with building exposure should alert the HCP to the possibility of building-related allergy.

c. It is unknown how much exposure time is required before sensitivity to mold develops. As many molds are commonly found outside of the workplace, it is expected that some individuals have been sensitized prior to any occupational exposure. Further, since development of allergies to some substances may take over 30 years of exposure, Reference 13.4-40, it is probable that in certain individuals, sensitization develops only after many years.

9. Health Considerations of Specific Molds

a. Aspergillus.

(1) *Aspergillus* species molds are commonly found. Three types of *Aspergillus*-related lung disease are recognized: 1) colonization of airways, 2) allergic disease including extrinsic allergic alveolitis, asthma, allergic bronchopulmonary aspergillosis, bronchocentric granulomatosis and chronic eosinophilic pneumonia (possibly progressing to allergic granulomatosis and angiitis, also called Churg-Strauss syndrome) and 3) invasive infections such as pseudomembranous tracheobronchitis, acute bronchopneumonia, angioinvasive aspergillosis, chronic necrotizing aspergillosis and invasive pleural disease, References 13.4-41 and 13.4-42. Both hypersensitivity and infection may be present simultaneously (i.e., a person with an allergic reaction to *Aspergillus* may also have an *Aspergillus* infection), Reference 13.4-43. Inhalation of *Aspergillus* conidia or mycelium fragments may result in airway colonization, which may subsequently cause infections in susceptible hosts, and may simultaneously induce hypersensitivity (allergic bronchopulmonary aspergillosis, ABPA), References 13.4-11 and 13.4-44. A significant relationship was found between the incidence of invasive nosocomial aspergillosis and the degree of fungal contamination of air and surfaces in patient rooms in a bone marrow transplantation unit and two hematology wards, Reference 13.4-45. As an antigen, hypersensitivity to *A. fumigatus* may cause *Aspergillus* asthma and ABPA, Reference 13.4-46. Specific IgE and IgG may be detected in ABPA. Chest X-rays are characterized by fleeting pulmonary infiltrates that are often confused with pulmonary tuberculosis, and by central bronchiectasis on chest computerized tomography. Early diagnosis and therapy may alter the course of the disease and prevent the development of end-stage lung fibrosis, Reference 13.4-47.

(2) *Aspergillus candidus*, common in grain dust, has been suggested to be an etiologic factor in organic dust toxic syndrome, Reference 13.4-48, and to pose an important occupational hazard for grain handling workers through its immune-modulating properties, Reference 13.4-49.

(3) *Aspergillus versicolor* has been found in an investigation of building-related complaints, but no association was seen between IgE or IgG antibodies and the presence of disease, Reference 13.4-50.

b. Stachybotrys.

(1) *Stachybotrys chartarum* (also called *Stachybotrys atra*) has been known as an animal pathogen, and has attracted attention as possibly having a role in human IEQ-related disease, Reference 13.4-51. It is a toxigenic fungus frequently found in water-damaged buildings, Reference 13.4-52. In one study, *S. chartarum* was identified in the indoor air in 6% of the buildings studied and in the outdoor air of 1% of the buildings studied, Reference 13.4-53. *S. chartarum* can produce volatile organic compounds that are quite different from those produced by Aspergillus, Reference 13.4-54.

(2) *S. chartarum* produces trichothecene mycotoxins, which are biologically active and can produce a variety of physiological and pathologic changes in humans and animals, including modulation of inflammation and altered alveolar surfactant phospholipid concentrations, Reference 13.4-55. Sensitivity to *Stachybotrys* has been found to involve both immunoglobulins IgE and IgG against antigenic proteins of *S.* chartarum, Reference 13.4-56. Effects of *S. chartarum* may be related to direct irritant as well as immunologic properties. Inhalation of *S. chartarum* extract aerosols was observed to provoke sensory irritation in the airways of both naive and immunized mice, Reference 13.4-57. Alveolar type II cells are sensitive to exposure to *S. chartarum* spores and mycotoxin (isosatratoxin-F, a trichothecene), Reference 13.4-58.

(3) *S. chartarum* has been associated with nasal bleeding in adults. Stachylysin, a mycotoxin, may be one chemical responsible for the hemorrhagic effects, Reference 13.4-59. Stachyrase A, a chymotrypsin-like proteinase from *S. chartarum*, has been isolated from a child with pulmonary hemorrhage, Reference 13.4-60. A possible association between *S. chartarum* and pulmonary hemorrhage and hemosiderosis in infants has been reported, but further review of evidence by the CDC and other experts concluded that the association was unproven, Reference 13.4-61.

(4) Articles are not consistent as to the significance of *Stachybotrys* in relation to human health. Two reviews have found inadequate evidence to clearly establish the place of *Stachybotrys* in human disease, Reference 13.4-62 and 13.4-63.

10. Other Molds and Mold-Related Organisms

a. Thermophilic Actinomyces and Aspergillus fumigatus have been suggested as possibly having a causative antigenic role in stipatosis, a hypersensitivity pneumonitis found in Mediterranean-area stucco workers exposed to those organisms in esparto grass (Stipa

tenacissima), Reference 13.4-64. (Although the name Actinomyces suggests a fungus, actinomycosis is a bacterial infection.)

b. Cladosporium cladosporioides was found to be the etiologic agent of hypersensitivity pneumonitis associated with a hot tub, Reference 13.4-65. Skin sensitization to C. cladosporioides was the most commonly found mold skin sensitization in a small population in Toronto, Canada, Reference 13.4-66.

c. Fusarium species infections in a hospital led to an investigation that identified the water distribution system of the hospital as the reservoir of Fusarium. Aerosolization of Fusarium species was documented after running the showers, Reference 13.4-67.

d. IgG to Sporobolomyces salmonicolor was the most commonly detected anti-mold immunoglobulin associated with exposure in a Finnish military hospital building with severe, repeated and enduring water and mold damage. Rhinitis, asthma and alveolitis were noted among personnel reacting positively to S. salmonicolor provocation tests, Reference 13.4-68.

e. Streptomyces albus was found to be responsible for a biopsy-proven case of hypersensitivity pneumonitis, Reference 13.4-69.

f. An increased risk of developing asthma in adulthood has been found to be significantly related to IgG antibodies to Trichoderma citrinoviride (but not to other molds), Reference 13.4-70.

g. Allergic bronchopulmonary mycosis caused by Schizophyllum commune in an otherwise healthy woman has been reported, Reference 13.4-71.

h. Acute eosinophilic pneumonia with precipitating antibodies to Trichosporon cutaneum, Trichoderma viride, as well as Aspergillus species has been reported, Reference 13.4-72. Other fungal species isolated from individuals with similar pulmonary disease include Candida albicans, Penicillium, Geotrichum candidum, Stemphylium lanuginosum, Culvularia lunata and Drechsleria hawaiensis, Reference 13.4-73.

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NOTE: Article abstracts with PMID numbers can be searched at National Center for Biotechnology Information, U.S. National Library of Medicine, PubMed query. Search using just the number.

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Section Five – Risk Communication and Mold

1. General

Risk Communication is an interactive process or exchange of information and opinions among interested parties or stakeholders, concerning a risk, potential risk or perceived risk to human health, safety or the environment.

a. Exposure to mold in the workplace and in military housing units has become a risk communication challenge for many Navy and Marine Corps industrial hygienists, safety specialists and health care providers. Years ago, most people thought of mold mainly in terms of mildew in the shower or fuzzy green spots on stale bread. There was virtually no perception among the public of health risks from exposure to mold. In recent years, there has been substantial media coverage on the health risks of exposure to indoor mold. The media and social media are more and more reporting on the threats of what they are calling “toxic mold”. This coverage, coupled with real or perceived increases in asthma rates and sensitivity to allergens, has caused a shift in public perception of the health risks from exposure to mold. What was once seen as just a nuisance by most people is now considered a serious health threat by many. Because of this perception of risk, it is very important for Navy installations and housing located in areas prone to indoor mold occurrence (e.g., hot, humid, etc.) to develop risk communication plans to prevent a communication crisis or communicate effectively if a crisis does occur.

b. A proactive risk communication strategy is designed to share information early with people to prevent situations in which high concern and low trust can lead to conflict and to help resolve conflict if it does occur by enabling people to make their own informed decisions about health risks using information from credible sources. Developing a risk

communication plan requires knowledge of risk communication principles and techniques.

c. The information in this section is provided as an overview of risk communication principles and guidelines to follow and techniques to use in an effective Mold Risk Communication Plan (MRCP). It is intended as a desk reference or guidance document for industrial hygienists who are responsible for IEQ issues such as mold. Personnel responsible for these issues are encouraged to attend formal risk communication training prior to developing or executing their plans and interacting with concerned stakeholders.

2. Identify and Prioritize Your Stakeholders and Their Needs

a. You must identify and prioritize your audience before you can develop any specific actions or strategies. There will likely be different groups of people that you need to communicate with in different ways concerning mold issues. You need to identify all of the people who are likely to be interested in, concerned about or affected by the potential risk or risk management decisions. These people are referred to as the *stakeholder groups*.

b. Your list of stakeholders will vary by issue and location, but for most mold issues will include groups of people such as: housing residents, building workers, building supervisors, maintenance or cleanup workers, housing managers, department heads, Commanding Officer's staff, legal staff, local Unions, safety staff, Navy health care providers, news media (Navy and civilian sources) and social media.

c. It is important to identify and research each stakeholder group to learn about their different information needs, including their perceptions of the health risks posed by mold. With health and safety risks, people often have a different perception of the magnitude of the risk than the actual risk number implies. There are four primary risk perception factors that affect how dangerous a person considers a health risk to be. They are trust, benefit, familiarity and control. Understanding these risk perception factors and the way these factors affect how people rank health risks is one of the building blocks of a good risk communication plan.

d. Do your stakeholders trust the risk managers? When a person trusts the people in charge of managing or controlling the risk and those providing information about the risk, then they are less likely to overestimate the dangers of the risk. Conversely, a person's fear or level of concern over the risk will likely go up if they do not trust that the risk manager and/or information source is openly sharing information or is not capable of safely handling the situation.

e. Are there any benefits to accepting the risk? If there is a benefit to the person from the action or situation, then they are more likely to consider a risk "acceptable." Without obvious benefits, people are more likely to become concerned about a risk that scientists and health care professionals may consider miniscule or "safe."

f. Is the risk a familiar one? When people are familiar with a risk or understand why the risk exists and how it is being managed, then they are less likely to become concerned unnecessarily.

g. Do the stakeholders have any control over the risk management process? Involving people early and often in the risk management process by openly sharing information is the best way to make people feel engaged and part of the process. When people feel engaged in the risk management process, their perceptions of the magnitude of the health risk is more likely to be in line with what the science and numbers are telling them. Whenever and as often as possible, give the stakeholders something concrete to do to help alleviate the risks, such as "how-to" information for safely disinfecting their own shower stall or procedures to report water leaks.

h. It is very important for you to understand your different stakeholders' perception of the health or safety risks concerning mold and your particular situation before you develop any communication strategies. Perception is reality for most people, so perceptions are typically not easy to change. If you are trying to convince people to change their perception, then you will need to examine each of the four risk perception factors and identify ways that you might be able to affect your stakeholders' level of trust, feeling of benefit, familiarity with the situation and feeling of control.

3. Goals and Objectives

a. After the first step identifying and prioritizing stakeholders, you can then decide on goals and objectives.

b. Communication goals typically fall into two categories for mold issues. They are proactive and reactive. A comprehensive MRCP will include goals and actions from both of these categories. Three typical mold communication goals for Navy activities are:
   (1) Educating Navy personnel in worksites or housing residents (Navy owned or Public Private Venture [PPV]) about mold and the potential health effects.
   (2) Directly engaging workers and residents in efforts to prevent mold growth.
   (3) Providing timely and appropriate information in the event of a mold "communication crisis" during which workers or residents are experiencing health effects or are concerned over potential health effects from exposure to mold.

4. Developing Communication Strategies

a. Different communication strategies need to be developed for each stakeholder group that are designed to provide both the information the Navy feels is important and the information that each particular group wants or needs to address their questions and concerns. These strategies are typically organized around the three M's of risk communication: Message (what to say), Media (how it should be said) and Messenger (who should say it).

b. Message Development.

(1) The underlying objective of any communication process is to exchange information or to convey a message. With health risk issues such as mold exposure, people typically are not primarily interested in all of the numbers and details of your investigation and cleanup. They are most often interested in finding out if they are safe and about what your organization has done to identify and reduce the health risks. More than a technical discussion of how small or large the problem is, people want to know what happened, what has been done or is being done to reduce and manage the mold problem and what plans are in place to prevent a similar problem in the future.

(2) A clear, concise and easily understood message is paramount when explaining health and safety risks. The content of your messages becomes even more critical during times of high concern as might occur if there is a mold problem in a school, office building or apartment complex. Research indicates that when people are angry or upset they have difficulty hearing and processing information. As much as 80% of the message may be ignored completely, forgotten or misinterpreted. The content and organization of your message becomes crucial in these situations. There are a few general rules about message development to help maximize the amount of information your audience hears, understands and remembers:

(a) Limit your information to 3 key messages that convey empathy/caring, honesty/openness and dedication/commitment.

(b) Keep messages short and simple (8th grade reading level or lower if possible), and avoid messages that convey only technical facts and information.

(c) Focus on action, both that has been taken and is planned for the future.

(3) Your key messages should each be backed up by technical facts and information. These facts should include reference to credible third party information sources that support your messages whenever possible. Some examples of credibly third parties might be the American Industrial Hygiene Association (AIHA), the Centers for Disease Control and Prevention (CDC), Environmental Protection Agency (EPA) or the state of local health department. This arrangement of key messages supported by fact is often referred to as “layering your information.” With most health risk issues, there will be stakeholders who are satisfied with the key messages, and then there will be others with varying interests or concerns that will want more detail and facts to satisfy their questions. By organizing your information in layers, you can provide your stakeholders with the amount of information that they want and need to address their personal concerns.

(4) There are several traps and pitfalls that you will want to avoid when developing messages that involve information on real, perceived or potential health risks. They are especially important to avoid if your mold issue has turned into one of high concern and/or low trust among your stakeholders. They include humor, negative terms, guarantees or absolute phrases (e.g. always, never, definitely), complex language and jargon, personal beliefs, attack (statements about the credibility of opposing groups/opinions), risk comparisons (do not use to justify a health risk only

to put numbers into perspective), worst case speculation and risk numbers or concentration values.

c. Choosing the Best Media.

(1) There are several different information channels that you could use to present information to the public or other interested stakeholders. Some examples include fact sheets, frequently asked questions (FAQs), web sites, press releases, social media (e.g., Facebook), site tours, small group meetings or public meetings. The media that you select should reflect the goal of your strategy and the level of concern or interest among your stakeholders.

(2) As discussed earlier, there are three primary goals for a typical Mold Risk Communication Plan. The first two goals, to identify stakeholders and educate them about mold and engage them in mold prevention efforts, can be the basis of a proactive risk communication strategy. There are several ways to proactively share mold information with personnel and residents. The following are just a few ideas:

(a) Post a fact sheet and/or FAQs on your facility's website or Facebook page.

(b) Advertise the importance for mold awareness through articles in your base paper or housing newsletter that highlight information in the fact sheet/FAQs and sources for more information at your facility.

(c) Send an information packet to all housing residents including the fact sheet/FAQs and a cover letter to grab attention and explain why you are providing the information.

(d) Encourage supervisors to discuss mold prevention in routine safety meetings.

(e) Post a fact sheet, on bulletin boards in public areas and work spaces, which is personalized with local point of contact for more information.

(f) Sponsor a base-wide mold awareness month during which all of the above efforts would be appropriate.

(3) During times of high concern over potential health effects from mold exposure, more one-on-one communication may be necessary to address fears or motivate action. Small group meetings may be necessary to talk individually with concerned people and address their needs. If large groups of people are involved, then a public meeting might be needed. Keep in mind that there is more than one format available for public meetings. With health and safety issues such as mold exposure, people typically have different levels of knowledge and different questions and concerns that are best addressed during one-on-one conversations with the subject matter experts. This is difficult to accomplish at the traditional "Town Hall" or "All Hands" public meeting format where there is a formal presentation(s) with people taking turns to ask questions. The best format to encourage one-on-one conversation and meet a variety of information needs is with an open house information session.

(4) An open house information session is essentially a poster display meeting. The meetings typically include 4 to 6 displays with each display focused on a key message or topic and manned by one or more subject matter experts. For example, with a mold problem you might have the following information displays:

(a) A summary of the history of the issue to answer the "what happened" question
(b) Highlights of actions taken or planned to correct the problem
(c) Plans to prevent future problems and ways that residents or workers can help in the future
(d) Educational materials on mold – what it is, how people can be exposed and potential health effects

(5) An open house format encourages stakeholders to circulate through various stations where they can gather information, view posters and talk one on one with subject matter experts. It is difficult to meet the needs of all of your stakeholders with a Town-Hall style meeting that typically involves one presenter and limits the number of people engaged in the question and answer segment due to time constraints and fears of public speaking.

d. Selecting a Messenger.

(1) One primary goal of risk communication is to establish trust and credibility. If your mold risk communication strategy involves public speaking, your messenger(s) is vital to achieving this goal. Selecting the spokesperson is just as critical to your communication process as deciding what to say. The person or persons selected to represent your organization must, at a minimum, have experience and feel at ease with public speaking. In addition, he or she needs to understand risk communication principles and the effect that his or her presentation style will have on the public's perception of risk. NMCPHC recommends that all subject matter experts manning posters at Open House meetings or other personnel representing your command have formal Risk Communication Training before discussing health risks with members of the public.

(2) The following are a few tips for trained risk communicators to keep in mind when preparing to speak with the public on health risk issues:
(a) Express empathy and concern early.
(b) Be aware of your body language because it can provide up to 75% of the final message content.
(c) Only answer questions that you are qualified to answer (especially important at Open House Meetings).
(d) Exercise caution with promises and commitments, only make promises you know you can keep and plan to keep all the promises you make.
(e) Anticipate the tough questions ahead of time by practice and role-playing and be prepared to answer even the most controversial questions.

(3) All representatives at public meetings need to be prepared to give consistent messages and answers to questions. There are several models to use in preparing answers to tough questions. For most situations, NMCPHC recommends the Six Part Model:
(a) Express empathy and concern.
(b) Provide a positive key message or conclusion that addresses the underlying concern or question, is short and is framed or "set off."

(c) Provide the first supporting fact or key message that includes endorsement by a credible third party if possible.
(d) Provide the second supporting fact or key message.
(e) Repeat exact positive key message or conclusion as stated (b) above.
(f) Describe future action and give contact information for further questions.

5. Risk Communication Assistance

a. There are several communication challenges that are common to most mold issues. NMCPHC can help you deal with these challenges and communicate effectively about issues concerning mold or other potential health risks. Services include:
   (1) Preparing and/or reviewing risk communication plans.
   (2) Profiling stakeholders.
   (3) Developing key messages and lists of anticipated questions and answers.
   (4) Developing and producing posters, fact sheets, FAQs, advertisements and press releases.
   (5) Planning and coordinating public meetings.
   (6) Evaluating presentations skills of your messengers.
   (7) Preparing presenters or poster experts to deal with angry or upset people and to answer tough questions.

b. To learn more about these services and about training opportunities:
   (1) Visit the NMCPHC Risk Communication website.
   (2) Industrial Hygiene Mold Information and Resources website.

Appendix 13.1-A

Back to Section 1.3 >>

WALK-AROUND INSPECTION LIST Page 1 of 18 Command _____ Building _____ Completed By _____ Date _____	
BUILDING DESCRIPTION	
Location of building in relation to potential sources (industry, landfills, emissions, outside renovations, etc.)	
Original construction date	
Original construction documents available	
Renovation date/Type of renovation	
Proximity and relation of renovation to complaint location	
Number of floors above grade	
Number of floors below grade	
Crawl space or slab construction	
Attic, basement or other unoccupied areas present	
Exterior wall construction material (wood, cinder block, brick, vinyl, vapor barriers, etc.) used	
Interior wall construction material (drywall, wallpaper, cinder block, etc.) used	
Flooring type (tile (asbestos, ceramic, etc.), carpet, vinyl, etc.) present	
Number of occupants	
Number of occupants building was designed for	
Times building occupied	
Types of work performed in different areas of the building	
Proximity and relation of types of work to complaint location	
Observations/Comments	
OFFICE USE ONLY File Number_____ Received By_____ Date Received_____	

WALK-AROUND INSPECTION LIST Page 2 of 18

Command _____ Building _____

Completed By _____ Date _____

HVAC GENERAL DESCRIPTION
(USE EPA SHORT AND LONG HVAC CHECKLISTS FOR MORE DETAILS)

Natural (windows open, etc.) or mechanical ventilation present and used	
HVAC system type/components present	
HVAC functioning properly	
HVAC controls set properly (dampers, thermostats, humidistats, etc.)	
Supply duct work insulation type present (interior, exterior, fiberglass, etc.)	
Filter type present	
HVAC system problems (component and description of problem - damper setting wrong, clogged drain, water in drip pan, missing or dirty filters, damaged or dirty duct insulation, thermostat not functioning properly, etc.)	
HVAC system turned off at times or when building not occupied	
Comfort or moisture problems caused if HVAC system turned off at times or when building not occupied	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 3 of 18

Command _____ Building _____

Completed By _____ Date _____

Supply, return, intake or exhaust vent locations	
Supply, return, intake or exhaust vent location problems (poorly located, blocked, etc.)	
Supply, return or exhaust vent condition (dirty, clean, etc.)	
Thermostat or humidistat locations	
Thermostat or humidistat location problems (poorly located, blocked, etc.)	
Thermostat or humidistat condition (functional, non-functional, etc.)	
Outdoor air intake locations in relation to exhaust vents and other potential sources	
HVAC system inspection and preventive maintenance schedule	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 4 of 18

Command _____ Building _____

Completed By _____ Date _____

POTENTIAL SOURCES – Building Use or Design	
Industrial or chemical work areas present in/around building	
Proximity and relation of industrial or chemical work areas to complaint location	
Chemical hoods or other industrial exhausts are vented properly or outside	
Industrial or chemical work areas and exhausts are away from outdoor air intakes	
Renovations/construction occurring in the building	
Proximity and relation of renovations/construction to complaint location	
Cooking areas present in in/around building	
Proximity and relation of cooking areas to complaint location	
Cooking area exhausts are vented outside	
Cooking areas exhausts are away from outdoor air intakes	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 5 of 18

Command _____ Building _____

Completed By _____ Date _____

Bathrooms present in building	
Proximity and relation of bathroom to complaint location	
Bathroom exhausts vented outside or room has openable windows	
Bathroom exhausts are away from outdoor air intakes	
Bathroom fans are operational during occupied hours (independently of light switch)	
Bathroom under slight negative pressure	
Blocked drains	
Dry sanitary traps	
Smoking areas present in/around building	
Proximity and relation of smoking areas to complaint location	
Smoking areas are outside and away from outdoor air intakes	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 6 of 18

Command _____ Building _____

Completed By _____ Date _____

Garage or loading dock areas present in/around building	
Proximity and relation of garage or loading dock areas to complaint location	
Garage or loading dock areas under slight negative pressure if connected to building	
Garage or loading dock areas are away from outdoor air intakes	
Combustion appliances (gas furnaces, gas water heaters, etc.) present in building	
Proximity and relation of combustion appliances to complaint location	
Combustion appliances are properly vented/not leaking	
Combustion appliance exhausts are away from outdoor air intakes	
Animals or pests evident in/around building	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 7 of 18

Command _____ Building _____

Completed By _____ Date _____

POTENTIAL SOURCES - Equipment or Materials

SPECIFIC LOCATION IN BUILDING_____

Types/Locations of office equipment or other equipment in/near complaint area	
Ancillary equipment (air cleaners, ionizers, humidifiers, dehumidifiers, portable fans, portable heaters, etc.) in/near complaint area	
Chemicals (cleaners, pesticides, toner, etc.) used in/near complaint area	
Frequency and duration chemicals are typically used	
New carpeting present in/near complaint area/Date of installation	
New materials, partitions or furnishings in/near complaint area/Date of installation	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 8 of 18

Command _____ Building _____

Completed By _____ Date _____

POTENTIAL SOURCES - Moisture Concerns

SPECIFIC LOCATION IN BUILDING_____

Water leaks known	
Location of water leaks	
Proximity and relation of leaks to complaint location	
Time since last water leak	
Flooding occurrence known	
Location of flooding	
Proximity and relation of flooding to complaint location	
Time since last flooding occurrence	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 9 of 18

Command _____ Building _____

Completed By _____ Date _____

Water stained or discolored ceiling tiles present	
Missing ceiling tiles	
Water stained or discolored ceilings present	
Water stained or discolored walls present	
Missing wall panels	
Water stained or discolored carpet present	
Water stained or discolored stored items present	
Proximity and relation of water stained areas/items to complaint location	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 10 of 18

Command _____ Building _____

Completed By _____ Date _____

Musty/moldy odors present	
Vinyl wall covering present on exterior walls	
Condensation present on exterior windows during winter	
High humidity present	
Basement/crawl space damp or standing water present	
Roof leaking or damaged	
Roof flashings leaking or damaged	
Attic space leaks or damage present	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 11 of 18

Command _____ Building _____

Completed By _____ Date _____

Potted indoor plants in poor condition or standing in water	
Other interior standing water sources (humidifiers, dehumidifiers, etc.)	
Condition of interior water sources (dirty, stagnant, etc.) within building	
Proximity and relation of standing water sources to complaint location	
Presence of areas producing a lot of water vapor (e.g. – possibly showers, kitchens, etc.)	
Do these areas have exhaust fans or are any appliances producing water vapor vented to the outside	
Proximity and relation of these areas to complaint location	
Visible biological contaminants (mold, etc.) present	
Proximity and relation of visible biological contaminants to complaint location	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 12 of 18

Command _____ Building _____

Completed By _____ Date _____

OCCUPANT COMFORT - General

SPECIFIC LOCATION IN BUILDING _____

Number of occupants in area	
Number of occupants area was designed for	
Times areas occupied	
Too hot/Too cold complaints	
Too humid/Too dry complaints	
Too stuffy/Too drafty complaints	
Odor complaints	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 13 of 18

Command _____ Building _____

Completed By _____ Date _____

OCCUPANT COMFORT - Cleanliness

SPECIFIC LOCATION IN BUILDING_____

Cleanliness complaints	
General cleanliness of area	
Odor complaints	
Occupant floor space uncluttered	
Occupant work stations clean	
Entry mats present	
Floors swept, vacuumed or mopped	
Floor sweeping, vacuuming or mopping frequency	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 14 of 18

Command _____ Building _____

Completed By _____ Date _____

Carpets vacuumed	
Carpet vacuuming frequency	
Vacuums have high efficiency filtration	
Carpet cleaning	
Cleaning frequency	
Type of carpet cleaning (steam, hot water extraction, dry chemical clean, etc.) used	
Upholstered furniture vacuumed/cleaned	
Upholstered furniture vacuuming/cleaning frequency	
Type of upholstered furniture cleaning (vacuum only, steam, hot water extraction, dry chemical clean, etc.) used	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 15 of 18

Command _____ Building _____

Completed By _____ Date _____

Fleecy cubical walls vacuumed	
Fleecy cubical walls vacuuming frequency	
General area dusted	
General area dusting frequency	
Recycling services available	
Trash receptacles emptied daily	
Housekeeping/Cleaning service schedules	
Observations/Comments	

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File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 16 of 18

Command _____ Building _____

Completed By _____ Date _____

OCCUPANT COMFORT - Lighting

SPECIFIC LOCATION IN BUILDING_____

Lighting complaints	
Type of lighting (fluorescent, incandescent, direct, indirect, general, task, etc.) present	
Lighting levels appropriate for work	
Light diffusers provide good dispersion of light	
Task lighting available and used if needed	
Outdoor lighting (windows, etc.) present	
Window treatments (blinds, shades) available and useable if needed	
Lighting problems (flickering lights, glare, etc.)	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 17 of 18

Command _____ Building _____

Completed By _____ Date _____

OCCUPANT COMFORT - Noise

SPECIFIC LOCATION IN BUILDING_____

Ambient noise levels complaints	
HVAC noise noticeable	
Employees in common work areas/cubicles or private offices	
Music system or personal radios used in common work area	
Speaker phones or computer programs (training, etc.) with sound on speaker routinely used in common work area	
Other noise sources present	
Employees use headphones/earphones for listening to telephone conversations, personal radios, computer programs (training, etc.) with sound, etc. in common areas	
White noise used in building	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

WALK-AROUND INSPECTION LIST Page 18 of 18

Command _____ Building _____

Completed By _____ Date _____

OCCUPANT COMFORT - Workstations

SPECIFIC LOCATION IN BUILDING_____

Workstation complaints	
Multi user workstation and chair adjustability	
Single user workstation and chair adjustability	
Workstations and chairs adjusted properly to the users	
Employees routinely perform work of ergonomic concern (large amounts of lifting, repetitive motion, awkward postures, etc.)	
Site has established a formal ergonomics program	
Employees received appropriate ergonomic training for their work	
Observations/Comments	

OFFICE USE ONLY

File Number_____ Received By_____ Date Received_____

Appendix 13.1-B – Sampling Methods*

Back to Section 1.3 >>

Suspected Contaminant	Possible Sampling Method** (Consult the sampling method and media guidance provided by the laboratory being used for analysis.)
Temperature	▪ Thermometer ▪ WBGT meter
Humidity	▪ Psychrometer (aspirated or sling)
Ventilation	▪ Air flow measuring equipment (e.g., flow hood, thermoanemometer, pitot tube) ▪ Ventilation smoke tubes or candles ▪ Tracer gas
Carbon dioxide	▪ Detector tubes ▪ Direct reading ▪ Gas sampling bag
Carbon monoxide	▪ Detector tubes, ▪ Direct reading ▪ Gas sampling bag
Formaldehyde	▪ 2,4-DNPH-treated silica gel tube ▪ Waters XPO SURE 2,4-DNPH Pouch media. ▪ Passive monitor
Nitrogen oxides	▪ Detector tubes ▪ Direct reading ▪ Two glass tubes each containing 400 mg Triethanolamine-impregnated molecular sieve separated by an oxidizer tube containing 1 gm of a chromate compound
Ozone	▪ Detector tubes ▪ Direct reading ▪ Two impregnated glass fiber filters (37mm polystyrene cassette) coated with a solution containing $NaNO_2$, K_2CO_3 and Glycerol in water
Particulates	▪ Tared or matched weight filters – Total ▪ Cyclone – Respirable ▪ Inhalable sampler - Inhalable ▪ Direct reading
Radon	▪ Electret passive radon monitor ▪ Direct reading ▪ Track-etch detector
Sulfur dioxide	▪ Detector tubes ▪ Direct reading ▪ Mixed cellulose ester filter followed by cellulose filter treated with Na_2CO_3 ▪ Impregnated activated beaded carbon tubes

Volatile organic compounds [total VOCs or individual VOC (e.g., solvent, pesticide)]	▪ Direct reading (Total VOCs or VOC of interest) ▪ Passive monitor (Total VOCs or VOC of interest) ▪ Sorbent tubes (VOC of interest) ▪ Thermal desorption tubes (Total VOCs screening) ▪ Vacuum canister (Total VOCs or VOC of interest)
Environmental tobacco smoke	▪ Sample for components (CO, NOx, Aldehydes, etc.)

***"IEQ meters" are available that combine relative humidity, temperature and carbon dioxide sampling into a single unit. Depending on the manufacturer, additional sensors may be purchased for some chemicals (e.g., ammonia, carbon monoxide, hydrogen, hydrogen sulfide, nitrogen oxides, oxygen, ozone, sulfur dioxide, VOCs) and particulates. IEQ meters usually have datalogging capabilities that are useful for establishing contaminant patterns throughout the affected work area and/or building.

**Consult the Industrial Hygiene Sampling Guide if using the Navy Comprehensive Industrial Hygiene Laboratories.

Appendix 13.1-C – Indoor Air Contaminant Guidelines and Recommendations (Non-Industrial)

Back to Section 1.4 >>

1. Abbreviations

Bq = Becquerels	µg = microgram
clo = clothing thermal insulation value	mg = milligram
cfm = cubic feet per minute	ng = nanogram
m^3 = cubic meter	ppb = parts per billion
ºF = degrees Fahrenheit	ppm = parts per million
L = liter	% = percent
met = metabolic rate	pCi = picoCuries (pico = 10^{-12}; 1 curie = $3.7x10^{10}$ Bq; 1 pCi/L = 37 Bq/m^3)

2. Chemical Sources

a. Cadmium.
Reference 13.1C-1a — 5 ng/m^3, annual average

b. Carbon Dioxide.
Reference 13.1C-2 — ≤ 700 ppm above acceptable outdoor air concentrations typically satisfies a substantial majority (~ ≥80%) of visitors with respect to human bioeffluents (body odor). 300-500 ppm is a typical range of acceptable outdoor air concentrations of CO_2.

c. Carbon Disulfide.
Reference 13.1C-1a — 100 µg/m^3, 24 hour average
20 µg/m^3, 30 minute average

d. Carbon Monoxide.
Reference 13.1C-3 — 35 ppm, 1 hour average (not to be exceeded more than once per year) (primary)
9 ppm, 8 hour average (not to be exceeded more than once per year) (primary)
Reference 13.1C-1c — 100 mg/m^3, 15 minute average
35 mg/m^3, 1 hour average
10 mg/m^3, 8 hour average
7 mg/m^3, 24 hour average
Reference 13.1C-4 — 9 ppm (not to exceed 2 ppm above outdoor levels), maximum concentration

e. 1,2-Dichloroethane.

Reference 13.1C-1a 0.7 mg/ m^3, 24 hour average

f. Dichloromethane.
Reference 13.1C-1a 3 mg/m^3, 24 hour average
0.45 mg/m^3, week average

g. Environmental Tobacco Smoke (ETS).
Reference 13.1C-1a No evidence for a safe exposure level

h. Formaldehyde.
Reference 13.1C-1c 0.1 mg/m^3, 30 minute average
Reference 13.1C-4 27 ppb, maximum concentration
16.3 ppb, Healthcare Only, maximum concentration

i. Hydrogen Sulfide.
Reference 13.1C-1a 0.5 µg/m^3, annual average
150 µg/m^3, 24 hour average
7 µg /m^3, 30 minute average

j. Lead.
Reference 13.1C-3 0.15 µg/m^3, rolling 3 month average (Not to be exceeded) (primary and secondary)
Reference 13.1C-1a 0.5 µg/m^3, annual average

k. Manganese.
Reference 13.1C-1a 0.15 µg/m^3, annual average

l. Mercury.
Reference 13.1C-1a 1 µg/m^3, annual average

m. Naphthalene.
Reference 13.1C-1c 0.01 mg/m^3, annual average

n. Nitrogen Dioxide.
Reference 13.1C-3 100 ppb, 1 hour average (98th percentile, averaged over 3 years) (primary) 53 ppb, annual average (arithmetic mean) (primary and secondary)
Reference 13.1C-1c 200 µg/m^3, 1 hour average
40 µg/m^3, annual average

o. Ozone.
Reference 13.1C-3 0.075 ppm, 8 hour average (Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years) (primary and secondary)
Reference 13.1C-1b 100 µg/m^3, 8 hour average
Reference 13.1C-4 0.075 ppm, maximum concentration (for buildings in EPA nonattainment areas)

p. Particulates $PM_{2.5}$.

Reference 13.1C-3	35 µg/m^3, 24 hour average (98th percentile, averaged over 3 years) (primary and secondary) 12 µg/m^3, annual average (arithmetic mean) (annual mean, averaged over 3 years) (primary) 15 µg/m^3, annual average (arithmetic mean) (annual mean, averaged over 3 years) (secondary)
Reference 13.1C-1b	25 µg/m^3, 24 hour average 10 µg/m^3, annual average
Reference 13.1C-4	15 µg/m^3, maximum concentration (for buildings in EPA nonattainment areas or local equivalent)

q. Particulates PM_{10}.

Reference 13.1C-3	150 µg/m^3, 24 hour average (not to be exceeded more than once per year on average over 3 years)
Reference 13.1C-1b	50 µg/m^3, 24 hour average 20 µg/m^3, annual average
Reference 13.1C-4	50 µg/m^3, maximum concentration 20 µg/m^3, Healthcare Only, maximum concentration

r. Styrene.

Reference 13.1C-1a	0.26 mg/m^3, week average 70 µg /m^3, 30 minute average

s. Sulfur Dioxide.

Reference 13.1C-3	75 ppb, 1 hour average (99th percentile of 1 hour daily maximum concentrations, averaged over 3 years) (primary) 0.5 ppm, 3 hour average (not to be exceeded more than once per year) (secondary)
Reference 13.1C-1b	500 µg/m^3, 10 minute average 20 µg/m^3, 24 hour average

t. Tetrachloroethylene.

Reference 13.1C-1c	0.25 mg/m^3, annual average

u. Toluene.

Reference 13.1C-1a	0.26 mg/m^3, week average 1 mg /m^3, 30 minute average

v. Vanadium.

Reference 13.1C-1a	Below 1 µg/m^3, 24 hour average

w. Volatile Organic Compounds (VOCs) and Total VOCs (TVOCs).

(1) VOCs

Reference 13.1C-2	Concentrations of concern must be determined for each individual compound.

(2) TVOCs

Reference 13.1C-2	Precise guidance on TVOC concentrations cannot be given. Setting target concentrations for TVOCs is not recommended. Setting target concentrations for specific VOCs of concern is preferred.
Reference 13.1C-4	500 µg/m3, maximum concentration 200 µg/m^3, Healthcare Only, maximum concentration
Reference 13.1C-5	Expect complaints when >5 mg/m^3

3. Physical Sources

a. Relative Humidity and Temperature.

Reference 13.1C-2	≤65% relative humidity for mechanical systems with dehumidification capabilities. Exceptions include spaces where processes or occupancy requires higher humidity conditions or that are designed and constructed to manage moisture. (e.g., kitchens, refrigerated or frozen storage rooms, ice rinks, hot tub rooms, shower rooms, pools, spas)
Reference 13.1C-6	There is no recommended lower humidity limit for thermal comfort. However, non-thermal comfort factors (e.g., drying or irritation of skin, eyes or mucus membranes, static electricity) may limit the lower humidity based on occupant acceptability.

See Figure 5.3.1 of Reference 13.1.C-6. This figure has a chart that shows typical temperature and humidity ranges that provide 80% occupant satisfaction for thermal comfort for spaces where occupants have activity levels that produce a metabolic rate between 1.0 – 1.3 met and wear clothing that provides between 0.5 – 1.0 clo of thermal insulation. This chart takes only thermal comfort into consideration, not conditions to prevent growth of biological contamination nor conditions to prevent discomfort from dryness. The ranges roughly fall between ~67 ºF with ~83% relative humidity to ~83 ºF with ~<10% relative humidity, depending on clothing. Refer to the referenced chart for details.

See below for rough examples of acceptable temperature ranges from the chart at two relative humidity levels for the two clothing groups. Please keep in mind that the indoor temperatures are operative temperatures that combine Dry Bulb Temperature and Mean Radiant Temperature. Dry Bulb Temperature can be used as a proxy for operative temperature under certain conditions. See Reference 13.1.C-6 Informative Appendix C for other specific information.

Table 13.1-C-1

Operative Temperature and Relative Humidity for 80% Occupant Acceptability with given Garment Thermal Insulation Clo values

1.0 clo Heavier Clothing Cooler Outdoor Environment Indoor Operative Temperature	0.5 clo Lighter Clothing Warmer Outdoor Environment Indoor Operative Temperature	Relative Humidity %
~70 to ~78	~76 to ~82	~20
~69 to ~76	~75 to ~80	~50

See Reference 13.1C-6, Figure 5.3.1 for actual acceptable ranges of acceptable operative temperature and humidity.

Reference 13.1C-6 See Figure 5.4.2 of Reference 13.1.C-6. This figure has a chart that shows typical temperature ranges that provide 80% or 90% occupant satisfaction for thermal comfort for spaces that are naturally conditioned (opening/closing windows) where occupants have activity levels that produce between 1.0 – 1.3 met. Since this chart takes into consideration people's clothing adaptation in naturally conditioned spaces by relating acceptable indoor temperatures and outdoor temperatures, clo values do not need to be estimated. This chart also does not require humidity or air speed measurements. See below for rough examples of acceptable temperature ranges at three mean monthly outdoor temperatures for the two occupant satisfaction levels. Please keep in mind that the indoor temperatures are operative temperatures that combine dry bulb temperature and mean radiant temperature. Dry bulb temperature can be used as a proxy for operative temperature under certain conditions. See Reference 13.1.C-6 Informative Appendix I for specific information.

Table 13.1-C-2

80% Acceptability Limits Indoor Temperature Range ºF	90% Acceptability Limits Indoor Temperature Range ºF	Monthly Outdoor Temperature ºF
~63 to ~76	~65 to ~74	50
~69 to ~81	~71 to ~79	68
~74 to ~87	~76 to ~85	86

See Reference 13.1C-6, Figure 5.4.2 for actual acceptable ranges of operative temperature.

b. Radon (Radiation)

Reference 13.1C-7	4 pCi/L (fix problem) 2 – 4 pCi/L (consider fixing problem) 1.3 pCi/L (average indoor level) 0.4 pCi/L (average outdoor level)
Reference 13.1C-8	100 Bq/m3, annual average (recommended national reference level) 300 Bq/m3, annual average (if 100 Bq/m3, annual average, cannot be implemented under the prevailing country specific conditions)

c. Ventilation

Reference 13.1C-2	Office spaces - 17 cfm outdoor air/person Classrooms – 13-15 cfm outdoor air/person Lecture classroom/hall - 8 cfm outdoor air/person Libraries – 17 cfm outdoor air/person Auditorium – 5 cfm outdoor air/person Cafeteria – 9 cfm outdoor air/person (Default combined outdoor air rate) (See Table 6.2.2.1 for full listing and notes on minimum ventilation rates in breathing zone.)
Reference 13.1C-2	General ventilation to dilute human bioeffluent odors, to satisfy a substantial majority of visitors to a space with sedentary persons – 15 cfm outdoor air/person (Informative Appendix C)

4. References

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Appendix 13.2-A – Mycotoxins

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1. General

While we are familiar with a few mycotoxins that cause adverse health effects and even death in humans, other toxins are poorly understood. Health effects associated with mycotoxins, particularly from inhalation exposures, are controversial and more studies are needed. Additionally, we do not know the synergistic effects of exposure to multiple mycotoxins simultaneously, nor do we understand mycotoxin degradation and possible by-products. Further, the amount of mycotoxin needed to elicit an effect varies among people (due to differing levels of sensitivity), as well as among the toxins themselves (differences in potency).

2. Mycotoxins

a. Aflatoxin. Aflatoxin is one of the most potent carcinogens known to man and has been linked to a wide variety of human health problems. It is also mutagenic, hepatotoxic, cytotoxic and tremorgenic (compounds capable of producing serious muscle tremor and/or seizures in vertebrates). The FDA has established maximum allowable levels of total aflatoxin in food commodities at 20 parts per billion (Reference 13.2-A-1). The maximum level for milk products is even lower at 0.5 parts per billion. Aflatoxin is produced by *Aspergillus*, particularly the species *flavus*, *parasiticus* and sometimes *fumigatus*, and is usually associated with cultivation of maize and peanuts in warm and moist climactic conditions. However, the culprit species are not usually found in indoor environments or associated with building materials.

b. Alternariol. A cytotoxic compound derived from *Alternaria alternata.*

c. Cephalosporin. Toxin produced by *Acremonium* species that is used as a human antibiotic.

d. Citrinin. A nephrotoxin produced by *Penicillium* (*citrinin* and *expansum*) and *Aspergillus* species. Renal damage, vasodilatation and bronchial constriction are some of the health effects associated with this toxin.

e. Cytochalasin E. A toxin from *Aspergillus clavatus* that inhibits cell division and protein synthesis, is nephrotoxic and is considered carcinogenic.

f. Deoxynivalenol. See Vomitoxin

g. Fumonisin**.** A toxin associated with species of *Fusarium* (e.g., *monoliforme)* that is neurotoxic, hepatotoxic, nephrotoxic and carcinogenic. Fumonisin is commonly found in corn and corn-based products. The animals most affected by veterinary mycotoxicosis are horses and swine. Fumonisin toxin causes "crazy horse disease," or leukoencephalomalcia, a liquefaction of the brain. Symptoms include blindness, head butting and pressing, constant circling and ataxia, followed by death. Chronic low-level exposure in humans has been linked to esophageal cancer. The American Association of Veterinary Laboratory Diagnosticians (AAVLD) advisory level for fumonisin in horse feed is 5 parts per million (Reference 13.2-A-2).

h. Gliotoxin**.** An immunosuppressive toxin produced by species of *Alternaria, Penicillium* and *Aspergillus (flavus, parasiticus, fumigatus)*.

i. Ochratoxin A. Primarily produced by species of *Penicillium (verrucosum* and *viridicatum)* and *Aspergillus (ochraceus)*. Ochratoxin is damaging to the kidneys and liver and is also a suspected carcinogen. There is also evidence that it impairs the immune system.

j. Patulin. A mycotoxin produced by *Penicillium (expansum), Aspergillus* (*clavatus*) and a number of other genera of fungi. It is believed to cause tumors and hemorrhaging in the brain or lungs. It is usually associated with apple and grape spoilage.

k. Satratoxin H. A macrocyclic tricothecene produced by *Stachybotrys chartarum*, *Trichoderma viridi* and other fungi. High doses or chronic low doses are lethal. This toxin is abortogenic in animals, is believed to alter immune system function and makes affected individuals more susceptible to opportunistic infection.

l. Sterigmatocystin. A nephrotoxin and a hepatotoxin produced by *Aspergillus versicolor* and *nidulans*. This toxin is also considered to be carcinogenic.

m. Tenuazoic Acid. A nephrotoxic, hepatotoxic, & hemorrhagic toxin produced by *Aspergillus alternata*.

n. T-2 Toxin. A tricothecene produced by *Fusarium (poae* and *sporotrichoides)* that is one of the more deadly toxins (hemorrhagic, hepatotoxic, nephrotoxic and carcinogenic). If ingested in sufficient quantity, T-2 toxin can severely damage the entire digestive tract and cause rapid death due to internal hemorrhage. T-2 has been implicated in the human diseases alimentary toxic aleukia and pulmonary hemosiderosis. Damage caused by T-2 toxin is often permanent.

o. Tricothecenes. Mycotoxins produced by *Fusarium, Stachybotrys*, *Myrothecium, Trichoderma and Cephalosporium species*. The tricothecene toxins produced in grains by Fusarium species are usually associated with elevated humidity and temperature. Tricothecenes inhibit protein and DNA synthesis and interfere with growth, reproduction and the structural integrity of tissues. Primary diseases (mycitoxicoses) include alimentary toxic aleukia (ATA), stachybotryotoxicosis, moldy corn toxicosis and red-mold toxicosis. The most frequently encountered tricothecene toxins include T-2, 2-deoxynivalenol (DON or vomitoxin), nivalenol and diacetoxyscirpenol (DAS).

p. Vomitoxin (or Deoxynivalenol) (DON). Vomitoxin, chemically known as Deoxynivalenol, a tricothecene mycotoxin, is produced by several species of *Fusarium,* especially *graminraeum*. Vomitoxin has been associated with outbreaks of acute gastrointestinal illness in humans. The FDA advisory level for vomitoxin for human consumption is 1part per million.

q. Zearalenone. A mycotoxin produced by *Fusarium* molds. Zearalenone is similar in chemical structure to the female sex hormone estrogen and targets the reproductive organs.

3. Other Mycotoxins

a. Aflatrem.

b. Aspergillic Acid.

c. Austamide.

d. Chaetoglobosin C.

e. Chlamydosporol.

f. Cladosporin. Produced by *Cladosporium cladosporiodes*; used as an antibiotic

g. Cychlochlorotine.

h. Cyclopiazonic Acid. Produced by *Aspergillus* and *Penicillium*; causes kodua poisoning

i. Cyclosporin. Produced by *Tolypocladium inflatum*; immunosuppressive

j. Echinulin.

k. Emodin. Produced by *Cladosporium cladosporiodes*; used as an antibiotic

l. Epicladosporic Acid. Produced by *Cladosporium* species; causes immunosuppression

m. Ergot Alkaloids. Produced by *Claviceps purpurea*, *Cladosporium purpurea*; hallucinogenic and vasoactive (causes smooth muscles to constrict); causes ergotism (gangrene)

n. Ergovaline. Produced by *Acremonium coenophialum*; primarily a disease of grasses, especially fescue

o. Erythroskyrine.

p. Flavoglaucin.

q. Fumagillin.

r. Fumitremorgens. Produced by *Aspergillus* species; causes tremors and liver damage; carcinogenic and mutagenic

s. Griseofulvin. Produced by *Penicillium griseofulvum* and *viridicatum*; tumorigenic, teratogenic and hepatotoxic

t. Isotrichodermin.

u. Kojic Acid.

v. Luteoskyrin Rugulosin.

w. Maltoyzine.

x. Nigragillin.

y. 3-Nitropropionic. Produced by *Arthrinium* species; possibly associated with pediatric neurotoxicity

z. Paspaline.

aa. Penicillic Acid.

bb. Penicillin. Produced by *Penicillium chrysogenum*; used as an antibiotic

cc. Penitrem. Produced by *Penicillium (crustosum)* and *Aspergillus* species; tremorgenic and neurotoxic

dd. Phylloerythrin. Produced by *Pithomyces chartarum*; photosensitization and eczema

ee. Roridins. Produced by *Stachybotrys*; see verrucarins

ff. Roquefortine C. Produced by *Penicillium crustosum* and *expansum*; can be tremorgenic, neurotoxic, nephrotoxic and carcinogenic

gg. Rubratoxin (A & B). Produced by *Penicillium rubrum*; hepatotoxic

hh. Secalonic Acid D. Produced by *Penicillium oxalicum*; teratogenic

ii. Sporidesmin. Produced by *Pithomyces chartarum*; hepatotoxic

jj. Stachybocins. Produced by *Stachybotrys chartarum;* see verrucarins

kk. Verrucarins. Produced by *Stachybotrys chartarum*; inflammatory reactions, including dermatitis; immunosuppressive, hemotoxic and hemorrhagic

ll. Verrucosidin.

mm. Versicolorin A.

nn. Viomellein.

oo. Viridicatumtoxin.

pp. Xanthomegnin.

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Appendix 13.2-B – Microbiological Collection Methods by Analyte

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Resource Information may be available from individual laboratories offering these tests.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Allergens	Air Sampling Impaction into liquid (Impingers) Filtration Bulk/Surface sampling Bulk material collected directly Bulk material collected with a micro-vacuuming cassette or other vacuuming technique. (This is often used for carpet sampling.) Bulk material or dust with sterile swab	Immunoassay Fluorescent immunoassay Enzyme immunoassay (ELISA) Radio immunoassay (RAST) Multiplex ARray for Indoor Allergens (MARIA)	Analyzes viable and non-viable for available antigenic species. Antigen-antibody specific Cross-reactivity can occur. Typical sample allergens are dog, cat, rat, mouse, cockroach, dust mites, some fungi.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Bacteria and Fungi (Genetic identification)	<u>Air Sampling</u> Filtration <u>Bulk/Surface Sampling</u> Bulk material collected directly Bulk material collected with a micro-vacuuming cassette or other vacuuming technique. (This is often used for carpet sampling.) Bulk material or dust with sterile swab	<u>Bioassay</u> Polymerase Chain Reaction (PCR)	Analyzes viable & non-viable for genetic identification using genus or species-specific DNA primers. DNA primers limited.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Biological Contaminants/ Bioaerosols – Viable (Fungi, bacteria, etc.) (Identification and/or count)	Air/Bulk/Surface Sampling	Culture	Grow viable organisms into colonies on nutrient agar to better to identify and quantify the organisms. Impingers/Impactors/Cassettes/Filters/Vials/Containers require sterile collection. Reusable sampling equipment must be disinfected between uses to prevent cross contamination. Samples are collected on nutrient agar initially or can be collected in/on inert media and prepared for culture at the laboratory. Must take into account special media/growth requirements for certain genus/species when culturing. For air samples, must ensure the sampling method has sufficient collection efficiency in the size range(s) of the bioaerosols present or else you will not collect them. Requires several days for incubation. Of the viable organisms cultured, only a percentage of those will actually grow during incubation. Species cultured from a site may not be the most prevalent or important Reports only viable organisms, underestimating total. Large reference database. Identification can be made to the species level. Culturing can be done for all the viable sampling methods. Some of these sampling methods also allow you to choose other analysis methods instead of or in addition to culturing. Some sampling equipment is suitable for personal air sampling.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Biological Contaminants/ Bioaerosols – Viable (Fungi, bacteria, etc.) (Identification and/or count) (continued)	Air sampling Impaction into liquid (Impingers) Impaction onto agar Impaction onto water soluble collection media (e.g., Via-Cell™ cassettes) Filtration (e.g., Filter cassettes, Button sampler™, IOM sampler™, etc.) Collection into Eppendorf vials	Culture	Impaction into Liquid (Impingers): • Liquid can evaporate or spill. Use mineral oil to eliminate evaporation (sterile mineral oil for fungus and bacterial culture) • Water or water based impinger liquids are not recommended for collecting hydrophobic particles such as fungal spores. • Glycerol impinger liquids are not recommended for viable microorganism collection because microorganism may die from osmotic pressure. Impaction onto Agar: • Multistage impactors allow size selective sampling. • Must take into account special media/growth requirements for certain genus/species when choosing sampling media agar. • Some impactors require positive hole correction Impaction onto Water Soluble Collection Media: • Media can be used for direct microscopy. However, once media is diluted in water the solution can be transferred for culturing or bioassay/PCR or chemical analysis. Filtration: • Sterile filters required for culturing. • Standard filters can cause desiccation and limited viability. However, gelatin filters help to prevent desiccation and improve culturability. • Filtration methods tend to concentrate particles at center of filter.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
			• Electrostatic charges may be collection problem for regular filter cassettes. • Button samplers collect inhalable fraction. • IOM samplers™ using Multidust™ foam discs allow size select into inhalable, thoracic and respirable fractions. <u>Collection into Eppendorf vial:</u> • Product uses a cyclone sampler. • Gentle capture of sample and capable of sterile handling. • Spores are collected and retained in a viable condition. • The Eppendorf vial can be capped and refrigerated for subsequent evaluation.
Biological Contaminants/ Bioaerosols – Viable (Fungi, bacteria, etc…) (Identification and/or count) (continued)	<u>Bulk/Surface Sampling</u> Bulk material collected directly Bulk material collected with a micro-vacuuming cassette or other vacuuming technique. (This is often used for carpet sampling.)	<u>Culture</u>	Non-destructive. Templates and kits available. Desiccation of sample possible. Limited viability. No correlation to airborne results. Multiple samples should be taken.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
	Bulk material or dust with sterile swab		
Biological Contaminants/ Bioaerosols – Non-Viable (Fungi, pollen, mycelia, fiber, skin cells, fiberglass, etc.) (Identification and/or count)	Air/Bulk/Surface Sampling	Microscope	Direct microscopic examination to identify and quantify organisms. Impingers/Impactors/Cassettes/Filters/Vials/Containers require sterile collection. Reusable sampling equipment must be disinfected between uses to prevent cross contamination. For air samples, must ensure the sampling method has sufficient collection efficiency in the size range(s) of the bioaerosols present or else you will not collect them. For some organisms, there can be limited identification ability. Cannot distinguish some species. Background debris can interfere with identification. Some sampling equipment is suitable for personal air sampling.

Biological Contaminants/ Bioaerosols – Non-Viable (Fungi, pollen, mycelia, fiber, skin cells, fiberglass, etc.) (Identification and/or count) (continued)	Air sampling Impaction into liquid (Impingers) Impaction onto glass/plastic slides/cassettes or tape or metal (stainless) impactors Impaction onto water soluble collection media (e.g., Via-Cell™ cassettes) Filtration (e.g. - Filter cassettes, Button sampler™, IOM sampler™, etc.) Collection into Eppendorf vials.	Microscope	Impingers. • Liquid can evaporate or spill. Use mineral oil or glycerol to eliminate evaporation. • Water or water based impinger liquids are not recommended for collecting hydrophobic particles such as fungal spores. Impaction onto Glass/Plastic Slides/Cassettes or Tape or Metal (Stainless) Impactors. • Multistage impactors allow size selective sampling. • Some impactors allow size selection by adjusting the air flow rate (e.g., VersaTrap™ cassettes). • Many impactors with glass/plastic slides also have a sticky substance on the slide to help capture particles. • Wall cavity sampling adaptors available for some types of impactor cassettes. Impaction onto Water Soluble Collection Media. • Media can be used for direct microscopy. However, once media is diluted in water the solution can be transferred for bioassay/PCR or chemical analysis. Filtration. • Filters with grids can be purchased for counting. • Filtration methods tend toconcentrate particles at center of filter. • Electrostatic charges may be collection problem for regular filter cassettes. • Button samplers collect inhalable fraction. • IOM samplers™ using Mutidust™ foam discs allow size select into inhalable, thoracic and respirable fractions.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
			<u>Collection into Eppendorf Vial.</u> • Product uses a cyclone sampler. • Gentle capture of sample and capable of sterile handling. • The Eppendorf vial can be capped and refrigerated for subsequent evaluation.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Biological Contaminants/ Bioaerosols – Non-Viable (Fungi, pollen, mycelia, fiber, skin cells, fiberglass, etc.) (Identification and/or count) (continued)	Bulk/Surface sampling Bulk material collected directly Bulk material collected with a micro-vacuuming cassette or other vacuuming technique. (This is often used for carpet sampling.) Bulk material or dust with sterile swab Clear sticky tape or a sticky prepared slide placed directly over the surface to be sampled (If tape is used, place tape onto slide for transport.)	Microscope	Non-destructive. Templates and kits available. No correlation to airborne results. Multiple samples should be taken.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
β glucan (1,3)-β-D glucan (Fungal cell wall component)	Air Sampling Filtration	Bioassay Limulus amoebocyte lysate assay (LAL) Immunoassay. ELISA	β glucan is a cell wall component of all fungi; sampling is used as a marker for the presence of fungal contamination. Detects dead and living spores. Does not identify which fungal species is present.
Endotoxins (Gram negative bacteria toxins)	Air Sampling Filtration Bulk/Surface sampling Bulk material collected directly Bulk material collected with a micro-vacuuming cassette or other vacuuming technique. (This is often used for carpet sampling.)	Bioassay LAL Kinetic Chromogenic Assay Turbidimetric Assay	Cassettes/filters/vials must be sterile and endotoxin-free. Identifies toxins produced by gram negative bacteria. Can analyze air, dust or bulk material samples (including water samples). May be useful as a post-remediation sample after a sewage spill or backup. Have shown correlation between occupant symptoms and endotoxin concentrations.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Ergosterol (Fungal cell wall component)	Air Sampling Filtration	Chemical Assay High Performance Liquid Chromatography (HPLC) Gas Chromatography (GC) GC with Mass Spectrophotometry (MS)	Ergosterol is the main membrane sterol in most fungi. Sampling is used as a marker for the presence of fungal contamination. Detects dead and living spores. Does not identify which fungal species is present. Long-term stability before analysis.
Extracellular Polysaccharides (EPS) (Fungal secreted carbohydrates)		Immunoassay ELISA	EPSs are stable carbohydrates that are produced during fungal growth in the mycelial cell walls; sampling is used as biomarker for the presence of fungal contamination. EPSs have antigenic specificity, usually at the genus level.
Fatty Acids (Bacteria cell wall component)		Chemical Assay GC GC-MS	Fatty acids are cell wall components of bacteria. Analysis uses gas chromatography to determine the fatty acid profile and then compares results to a reference database using statistical pattern recognition software.

Analyte	Sample Information	Analysis Method(s)*	Sampling Notes
Microbial Volatile Organic Compounds (MVOCs) (Bacterial or fungal emissions)	Air Sampling Sorbent tube Summa canisters	Chemical Assay GC GC-MS	MVOCs are produced by bacteria or fungi. Organisms must be actively growing for organic compound production. Little consensus on which MVOCs are important or medically significant.
Mycotoxins (Fungal secondary metabolites)	Air Sampling Filtration Bulk/Surface sampling Bulk material collected directly Bulk material collected with a micro-vacuuming cassette or other vacuuming technique. (This is often used for carpet sampling.) Bulk material or dust with sterile swab	Chemical Assay Liquid Chromatography (LC) with MS HPLC GC/MS Solution fluorimetry Immunoassay ELISA	Mycotoxins are secondary metabolites produced by some fungi. Mycotoxins are typically produced when the fungus is stressed. Sensitive analytical methods may not be available for all indoor air mycotoxins. Agriculturally important toxins methods widely available. Air sampling for mycotoxins has important limitations and requires high concentrations of a fungus to ensure accurate detection.

*Culture (viable) - Collect or transfer sample onto nutrient agar to grow colonies for counting and/or morphological identification.
Microscope (non-viable) – Examine under microscope for counting and/or morphological identification.
Bioassay – Analytical method in which the result is an observable effect on or in a biological system/organism. Includes: PCR (genetic identification using DNA primers), LAL, kinetic chromogenic assay and turbidimetric assay.
Chemical Assay – Analysis of chemical compounds produced by or contained in the organism. Includes: HPLC, GC, GC-MS, LC-MS and solution fluorimetry.
Immunoassay – Analysis based on the specificity of an antigen-antibody reaction. Includes: Fluorescent immunoassay, ELISA and RAST.

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SOME COMMONLY USED INDOOR ANTIMICROBIAL PRODUCTS			
Antimicrobial[1]	**Action [2]**	**Advantages**	**Disadvantages**
Alcohols	B, F, V	non-staining; not irritating; non-corrosive	inactivated by organic matter; highly flammable; not effective against spores
Aldehydes (formaldehyde)	B, F, V, S**	inexpensive; not affected by organics	irritating; slow penetration rate; toxic
Chlorine dioxide			Extremely toxic; not recommended for treating occupied areas
Gluteraldehydes;	B, F, V, S**	not affected by organics; not corrosive; less toxic than aldehyde	irritating; expensive; slow penetration
Hydrogen peroxide	B, F, V, S**	stable at low concentrations	corrosive; degrades in heat and ultraviolet light; expensive
Hypochlorites (bleach)	B, F, V, S**	inexpensive	toxic; corrosive; inactivated by organic matter; removes color from fabrics; dissolves protein fibers (wool, silk); NEVER mix with ammoniated detergent (releases chlorine gas)
Iodophors (iodine compounds)	B, F, V, S**	stable; residual action	inactivated by organic matter; expensive; irritating
Ozone			Extremely toxic; not recommended for treating occupied areas
Phenolics	B, F, V	inexpensive; residual action; considered effective against vegetative (growing) bacteria and fungi	toxic; irritating; corrosive; not effective against spores
Quaternary Ammonia Compounds	B*, F, V*	inexpensive; relatively non-toxic; odorless; non-corrosive; stable	inactivated by organic matter; limited efficacy; not considered sporicidal

[1] The Environmental Protection Agency (EPA) registers and regulates antimicrobial pesticides under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). To obtain registration, manufacturers of antimicrobial products must meet the basic standards, the foremost being that the product will not cause unreasonable adverse effects to

human health or the environment and that product labeling and composition comply with the requirements of FIFRA. Full details on antimicrobial registration, labeling and data requirements are in 40 CFR Parts 152, 156 and 158.

[2] **ACTION Key**

B = bacteriocide
F = fungicide
V = virucide
S = sporicide

* Limited effectiveness
** Requires prolonged contact time

1. General

NOTE: The information below has been reproduced from the EPA's Pesticide Registration webpage as of September 2018.

Antimicrobial pesticides are substances or mixtures of substances used to destroy or suppress the growth of harmful microorganisms such as bacteria, viruses or fungi on inanimate objects and surfaces. Antimicrobial products contain about 275 different active ingredients and are marketed in many types of formulations including: sprays, liquids, concentrated powders and gases.

Today, approximately one billion dollars each year are spent on a variety of different types of antimicrobial products. More than 4000 antimicrobial products are currently registered with EPA and sold in the marketplace. Many of these products are registered to control infectious microorganisms and thus protect public health.

Antimicrobial pesticides have two major uses:

a. Disinfect, sanitize, reduce or mitigate growth or development of microbiological organisms;

b. Protect inanimate objects (for example floors and walls), industrial processes or systems, surfaces, water or other chemical substances from contamination, fouling or deterioration caused by bacteria, viruses, fungi, protozoa, algae or slime.

This category does not include certain pesticides intended for food use but does encompass pesticides with a wide array of other uses. For example, antimicrobial pesticides act as preserving agents in paints, metalworking fluids, wood supports and many other products to prevent their deterioration. Some examples of antimicrobial pesticide chemicals can be found in the Antimicrobial Chemical Indexes, which are available on the EPA Pesticide Web site.

2. Types of Antimicrobial Products

Antimicrobial products are divided into two categories based on the type of microbial pest against which the product works:

a. Non-public health products. Used to control growth of microorganisms of economic and aesthetic significance and are not considered to be human health related: algae, odor-causing bacteria, bacteria which cause spoilage, deterioration or fouling of materials and

microorganisms infectious only to animals. This general category includes products used in: cooling towers, jet fuel, paints, and treatments for textile and paper products.

b. Public health products. Intended to control microorganisms infectious to humans in any inanimate environment. The more commonly used public health antimicrobial products include the following:
   (1) Sterilant. Used to eliminate or destroy: fungi, fungal spores, viruses, vegetative bacteria, bacterial spores. Sterilization is critical to infection control and is widely used in hospitals on medical and surgical, instruments and equipment. Types of sterilizers include:
      (a) Sterilization by physical means (non-pesticidal): steam under pressure (autoclaving) or dry heat ovens (used primarily for sterilization of medical instruments).
      (b) Sterilization by chemical means (pesticidal): low temperature gas (ethylene oxide) (used primarily for sterilization of medical instruments) or liquid chemical sterilants (used primarily for delicate instruments which cannot withstand high temperature and gases).

c. Sporicide. Used to inactivate bacterial spores.

d. Disinfectants. Used on, nonliving surfaces and objects to destroy or irreversibly inactivate infectious fungi and bacteria but not necessarily their spores. Disinfectant products are divided into two major types:
   (1) Hospital type disinfectants are critical to infection control and are used on: medical and dental instruments, floors, toilet seats and other surfaces.
   (2) General use disinfectants are the major source of products used in: households, swimming pools and water purifiers.

e. Sanitizers. Used to reduce, but not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations. Sanitizers include:
   (1) Food contact products. These products are important because they are used on sites where consumable food products are placed and stored. Sanitizing rinses are used on surfaces such as: dishes and cooking utensils, equipment and utensils found in dairies, food-processing plants, eating and drinking establishments.
   (2) Non-food contact products. Non-food contact surface sanitizers include: carpet sanitizers, air sanitizers, laundry additives, in-tank toilet bowl sanitizers.

f. Germicides. A germicide is a substance or mixtures of substances that kill a number of microorganisms (e.g., viruses, fungi and bacteria).

Figure 13.3 Clearance Sampling Process

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