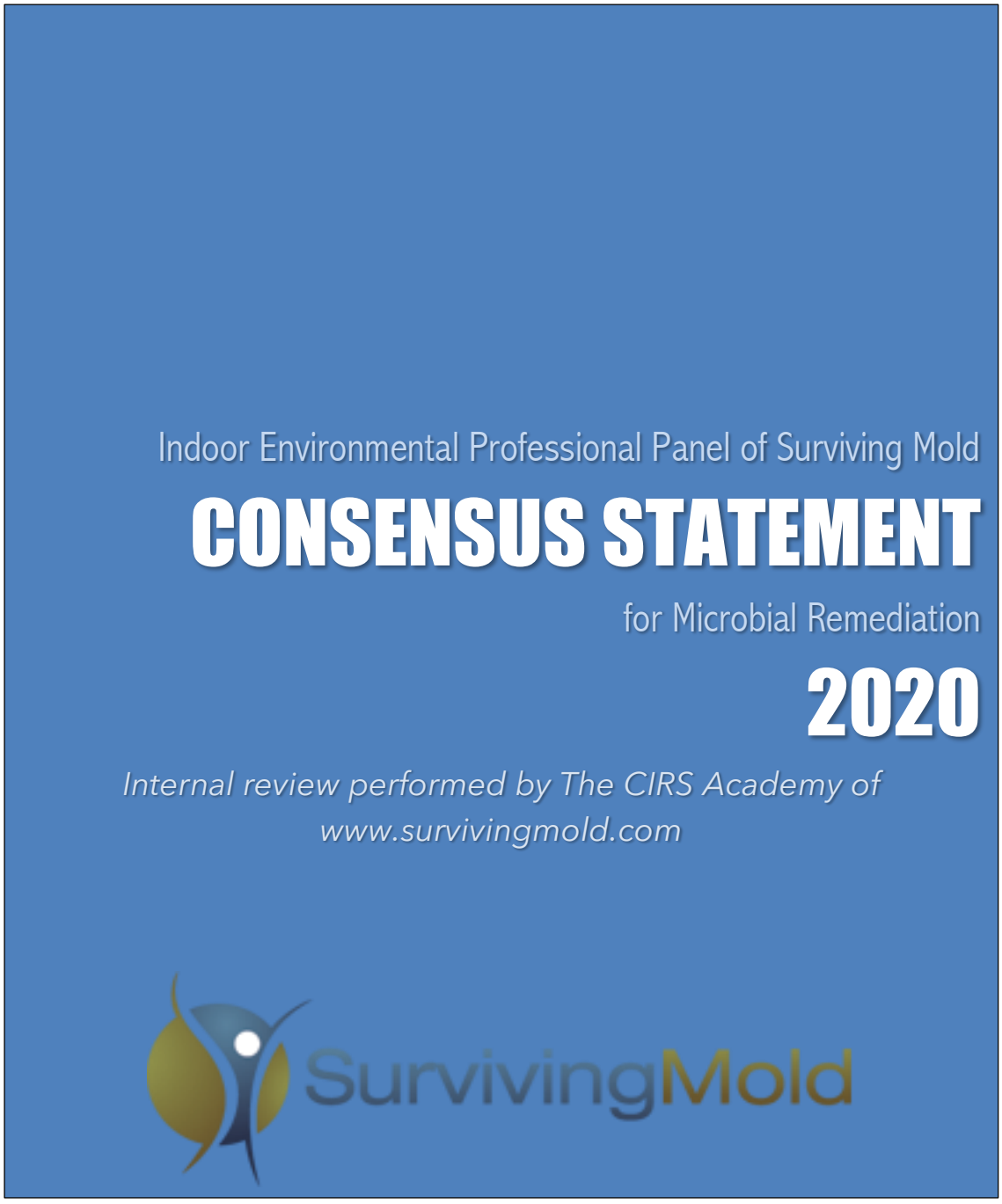
EDITORIAL

SURVIVING MOLD INDOOR ENVIRONMENTAL PROFESSIONAL PANEL CONSENSUS FOR MICROBIAL REMEDIATION 2020



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Abstract:

In the absence of Federal safety standards for occupancy of buildings with a history of water intrusion, remediation of water-damaged buildings (WDB) has focused on building health issues, including correction of defects in the building envelope, microbial growth and removal of contaminated materials. To date, no guidelines have been published that incorporate human health parameters into professional recommendations regarding treatment of the potentially unsafe conditions found in WDB. This document is a consensus statement that expands on existing professional society recommendations by including guidelines for remediation of buildings to be occupied by known, previously sickened patients.

1. Introduction

The primary mission for this consensus document is to provide specific guidance to Indoor Environmental Professionals, remediators, clinicians and patients that addresses medically important remediation and risk reduction principles for damp or WDB. "Medically important" means that remediation is being initiated in response to concerns regarding possible adverse health effects acquired following exposure to the indoor environment of a water-damaged building.

The focus audience(s) are individuals:

- suffering adverse health effects following exposure(s) to impacted interior environments;
- identified or diagnosed as being at risk of developing adverse health effects from exposure;
- desiring or needing a standard of care that emphasizes the health and wellbeing of occupants by addressing medically important remediation.

Some medically diagnosed conditions that may be considered under these broader definitions as part of differential diagnosis include but are not limited to:

- Chronic Inflammatory Response Syndrome (CIRS) following the guidance outlined in the Surviving Mold Medical Consensus, *Internal Medicine Review*, 2018.[1]
- Respiratory illnesses diagnosed as being exacerbated by microbial conditions, such as asthma and allergic disease.
- Immunocompromised individuals who have been diagnosed as being prone to microbial infections (e.g., Aspergillosis, immune compromised due to chemotherapy, anti-rejection transplant treatments, and other immune-suppressing conditions).
- Any other medical diagnosis by a health provider with appropriate training, education, and experience with building-related health issues consistent with the guidelines outlined in the 2008 US Government Accountability Office (US GAO) document.[2]

Although the primary intent is to focus on residential environments, these principles may also have applications for non-residential buildings including office, educational, and other occupied structures. This document is not intended to address hospitals, other health care facilities, manufacturing, or other industrial buildings. It is the intent of this consensus document to strongly emphasize the importance of addressing the wide variety of damages, biological organisms, and the harmful primary and secondary metabolites that may develop as a result of dampness or water damage, inappropriate maintenance, and dispersed in buildings via air pathways and movement caused by convection currents and stack effect.

Health issues thought to be caused by water-damaged buildings can sometimes be traced to previous inappropriate and/or incomplete restoration actions. Attempts to kill, encapsulate or

cosmetically cover-up or hide previous water-related microbiological conditions are rarely satisfactory and can result in harmful conditions for exposed persons.

The Indoor Environmental Professionals (IEP) Panel of Surviving Mold (SM) consensus body recognizes and acknowledges the following documents as basic, important principles for professional water-damage restoration and mold remediation:

- American National Standards Institute (ANSI)/Institute of Inspection Cleaning and Restoration Certification (IICRC) S500-2015 (4th edition) Standard and Reference Guide for Professional Water Damage Restoration ("S500").[3]
- ANSI/IICRC S520-2015 (3rd edition) Standard for Professional Mold Remediation ("S520").[4]

The S520 states,

> "Since every mold remediation project is unique, in certain circumstances, common sense, experience and professional judgement may justify a deviation from this Standard. Furthermore, this Standard is intended to be neither exhaustive nor inclusive of all pertinent requirements, methods or procedures that might be appropriate on a particular mold remediation project."

The SM IEP Panel has written this consensus document to function within the framework of the S500 & S520 Standards as it builds on the foundation they and other authoritative documents have established. Some occupants are made ill by substances in water-damaged buildings, creating a need for deviations. Since this document offers deviations from those Standards, its implementation may result in project limitations, complications, complexities, or conflicts that may be faced by the contractor, client, or other materially interested parties. Any remediation company or user of this document should inform the other parties how this document is being applied and the reason(s).

This document does not offer legal, medical, insurance coverage or tax advice. Every water damage, restoration, remediation, and casualty loss have differences that may impact financial considerations. We recommend that materially affected parties consult with appropriate experts to help them understand their options. Homeowner's insurance may cover some aspects of water damage, such as when it is sudden or accidental, while excluding or placing a cap on costs associated with microbial remediation. Insurance underwriters may report inquiries or claims to insurance databases, which may impact future insurance premium costs or even the ability to obtain future coverage. If a part of a casualty loss is not covered by insurance, a tax advisor can determine if costs may be deductible. A tax advisor may be able to advise if microbial remediation or other aspects of restoration can be considered a medical or disability expense necessary to make the home accessible for those diagnosed with a water damage-related disability. The ability to claim certain medical deduction expenses may require counsel with a tax advisor in conjunction with a physician. Each of these situations goes beyond the scope of this document.

Health care professionals may be able to provide valuable information regarding the indoor environmental conditions that need to be achieved and maintained for their patients' recovery and is recommended if possible.

Finally, if the methods described later in this document are adequate to protect "sensitized individuals," then those same methods also will be sufficient to protect less affected individuals and those that have not yet been sensitized.

This consensus document has been prepared by the group of Indoor Environmental Professionals, Building Scientists and Restoration Professionals who are acknowledged at the end of this document. The participants who prepared this document understand that "success" for affected individuals ultimately is determined by patient recovery. "The ultimate criterion for the adequacy of abatement efforts for treating biological contamination is the ability of people to occupy or re-occupy the space without health complaints or physical discomfort. Cessation of bioaerosol exposure should result in a cessation of bioaerosol-related symptoms."[5]

We note that removal from exposure is the first task in all related medical treatments we have seen. Remediation is a mechanism to stop exposure. We wish to acknowledge and thank the health care professionals who have reviewed and provided comments for this consensus document. Those comments have been reviewed, considered, and included as appropriate.

2. Disclaimers

The purpose of this document is to provide guidance that supports and builds on the remediation principles set forth in the S500, S520, and other authoritative references aimed specifically at medically important remediation.

This is considered a living document and, as such, is subject to change as new information or advances in science and understanding develop.

This document does not in any way provide a guarantee of success or outcome, regardless of any recommended protocol. Every microbial remediation project is unique and may be affected by other factors that are beyond the scope of this document.

3. Limitations of this Document

The scope of this document is limited to remediation and environmental cleaning efforts to reduce risks of biological exposures, which include (but are not limited to) resident fungi, actinomycetes, and other Gram-positive and/or Gram-negative bacteria growing in an amplified condition following water and moisture intrusions or damp conditions in a building.

Microbial environmental cleaning is any physical removal of microbial structures (e.g. cell wall materials, mycotoxins, MVOCs, endotoxins, actinomycetes), fragments, or spores that have transferred from an affected area to an otherwise unaffected area and either settled out or remained airborne. It can also include areas that have been cross contaminated by sources-such as humans, pets, vectors, possessions, or HVAC.

The goal is to provide a safe and healthful environment for all occupants, including those suffering from adverse health effects acquired following exposure(s) to the interior environment of buildings with a history of water damage or damp conditions.

Understanding that there is no such thing as a perfect environment, the goal, but not guarantee, is a risk-reduced environment that satisfies the needs of the client.

Although the document focuses on medically important remediation and cleaning efforts, it is not intended to provide medical advice or directives. Medical questions should be directed to qualified health care providers.

This document does not address hazardous or regulated materials including, but not limited to asbestos or lead-based paint, or other non-microbial concerns.

This document is neither intended to identify any or all causes, nor does it necessarily provide a solution to prevent current or future damage or exposure.

4. Communication and Documentation

In addition to the recommendations found in the S520 Section 9, this document recommends the following:

- Deviations from this document may be appropriate; such events/procedures should be discussed and documented in writing with all involved parties.
- There may be situations in which medical advice by a physician/clinician may be helpful. In such cases, all relevant medical communication should be with the consent of the involved parties and in accordance with any applicable Health Insurance Portability and Accountability Act (HIPAA) laws regarding patient confidentiality, requirements, or privacy rights.[6]
- Detailed communications regarding a client's health conditions are not usually necessary for remediation protocols, scope of work, or remediation practices. However, general communication may be necessary to help guide specific aspects of the remediation and for health and safety concerns for workers. As an example, communications from a physician that a patient is suffering from a condition like Legionnaires' disease may be important to help workers address contaminated environments and appropriate selection of PPE.
- Members of a remediation company may serve various responsibilities on the microbial remediation project. Good communication is essential to ensure that the scope of work provided on the estimate and remediation/cleaning protocols are being executed correctly on-site.
- Completing a task does not guarantee a goal has been achieved. This document promotes a goal-oriented model (versus task-oriented), which is not limited to a specific number of actions. Goal-oriented efforts, for example, focus on the physical removal and cleaning of air and surfaces until those areas have been returned to a normal microbial ecology.
- Detailed documentation of decisions made with the client is necessary to avoid future disputes.

5. Personal Protection Equipment (PPE)

In addition to what is mentioned in Section 8 of the S520, this document recommends the following:

- People with CIRS or an undiagnosed multisystem illness should not consider performing this work or exposing themselves to the interior environment of the WDB. In addition, according to Occupational Safety and Health Administration (OSHA) guidelines, those with cardiorespiratory illness should seek medical clearance before being subjected to the stresses of wearing personal protective equipment (PPE).[7]
- Remediation workers performing medically important remediation must understand the importance of properly donning and doffing PPE. When properly used, PPE protects the workers as well as others entering contaminated areas of the structure. The proper donning/doffing of PPE can also protect against potential cross-contamination concerns.
- At the discretion of the remediator, additional cleaning of PPE or supplies, materials, and/or equipment should also be considered when exiting a containment area or area deemed as contaminated.

- Respirators and other PPE that provide protection for workers at a level OSHA deems suitable may not be acceptable for residents or occupants entering contaminated areas in structures. Anyone wishing to enter a contaminated environment should be cautioned to get a medical opinion regarding their ability and suitability for wearing a tight-fitting respirator. Spirometry and other aspects of lung function may need to be evaluated. In isolated situations, occupants may intentionally or unintentionally enter a work area that is considered contaminated. The remediation company needs to take actions to minimize unintended breaches into the work areas to minimize exposure and cross-contamination concerns.
- Tight-fitting respirators provide greater protection; however, they also present greater risks due to resistance to breathing and the inability to draw enough air through the respirator based on the wearer's lung capacity. Lung capacity may provide an even greater level of physical burden for persons who are already medically compromised. Even physically fit workers are at risk to suffer from respiratory, heat, or physical exhaustion during extended periods of work while wearing respirators.
- There are concerns that safety glasses are not adequate to protect workers' eyes during overhead and aggressive demolition work, as there are concerns that ultrafine or nanoparticles and volatile organic compounds (VOCs) may circumvent the protection provided by safety glasses. In this instance, a full-face respirator or Powered Air Purifying Respirator (PAPR) provides better respiratory and eye protection.
- Double protective suits of differing color (for identification/tracking purposes) will enable movement from work area to decontamination unit. The goal is always to prevent cross-contamination.
- This document recommends not using hygiene products with added fragrance, as many individuals have sensitivities to them.

6. Practical considerations for microbial remediation and cleaning

Section 12 of the S520 provides a reasonable framework for containment setup and operation. This document recommends and highlights the following:

Containment, barriers and isolation

- To support what the S520-2015 cites in their Standard, containments should be set up prior to opening or disturbing any area suspected to contain or harbor microbial growth or contamination.
- This consensus body believes that wall-to-wall carpet and padding is difficult to restore and it is often not possible or feasible financially to effectively clean and verify that microbial spores and fragments have been removed. Thus, carpets should be considered for removal and replacement. Consider substituting non-porous (or "hard") flooring for carpet. The reinstallation of replacement carpet may not be appropriate for individuals who have environmental sensitivities.
- If physically possible, carpets should be removed from the containment area before remediation or disturbance begins. When doing so, use dust-suppression methods to remove and discard any carpet and padding, such as but not limited to, rolling up the carpeting, double-bagging or sealing, wiping down, and removing from containment area. If possible, remove carpeting through exterior access — e.g., window or door — that may exist within containment.

- If physical removal of carpet and padding cannot be performed or the client accepts the risk of keeping it in place, cover the carpet with adequate protection strong enough to prevent penetration for the duration of the containment project. (Note: please refer to the ANSI/IICRC S100-2015[8] for guidance regarding carpet-cleaning methods).
- Condition 3 (see text below this paragraph) containment dimensions should be left to professional judgment, but considerations should be made to limit or reduce physical size. Oversized containments should be avoided to minimize the challenges with contaminant control and clean-up efforts. Undersized containments may not facilitate adequate removal and remediation of affected materials.

  According to the IICRC S520-2015, Condition 3 refers to growth in an indoor environment contaminated with the presence of actual mold growth, associated spores, and fungal fragments. Actual growth includes growth that is active or dormant, visible, or hidden.

- When addressing areas affected by Condition 2 (see text below this paragraph) to include airborne contamination (as confirmed by IEP findings and sampling results), professional judgment should be used to determine whether any additional containment and engineering controls should be used. This would also involve direct communication with the IEP and discussions regarding their findings and sample results.

  Condition 2 (per the IICRC S520-2015): (settled spores or fungal fragments) an indoor environment which is primarily contaminated with settled spores or fungal fragments that were dispersed directly or indirectly from a Condition 3 area, and which may have traces of actual growth.

- The S520 (Section 12.1.1— Isolation)[4] calls for the use of fire-retardant polyethylene plastic and states when it should and shall not be used. In cases where containments are constructed with occupants who do not tolerate the oils or treatments (e.g., fire retardants or slip factors), it is suggested that Tyvek® HomeWrap® be considered as a better tolerated substitute product.
- Local exhaust ventilation techniques should be used to control dust created at the source of disturbance. This will help minimize cross-contamination of nearby surfaces/air. Whenever possible, areas being cut/disturbed should be performed within the capture zone — and with enough velocity to pull particles into the device — of the local exhaust inlet. The capture zone will vary between devices.
- Taping or sealing joints should not be performed as an alternative to appropriate cleaning of cracks and crevices (e.g., under sill plates, and where studs meet the backside of wall assemblies). Taping and sealing joints can serve as a temporary isolation of adjacent spaces where air infiltration may occur.

Engineering Controls

- The use of Negative Air Pressure and Positive Air Pressure differentials help contain the work being performed, as well as to protect the areas outside the defined workspace. When using air pressure differentials (either positive or negative), it is important to assess and identify air ingress and egress pathways for possible risk factors. Environmental conditions should be regularly monitored when any engineering controls are installed. Examples of risk factors include, but are not limited to
  - Hygrothermal conditions and duration of engineering controls;

  - Weather conditions (e.g., barometric pressure, wind);
  - Integrity of the enclosure;
  - Adjacent areas (e.g. interstitial cavities, crawlspaces, attics) exposed during remediation efforts affecting the intended pressure differentials (unintended pressure drop).
  - Maintenance and integrity of the Negative & Positive Air Pressure differential equipment.

- When using air pressure differentials, it is important to consider the source of make-up air to be sure its origin is fresh and uncontaminated. Where possible, make-up air should be filtered before entering the work area. Ideally, make-up air should be suitably located and travel across the work area towards the work being performed.
- Where Negative Air Pressure to outdoors is not an option and exhausting to the inside of a building is necessary, appropriate exhaust filters should be used. We recommend that all air-filtration devices that are being exhausted to the interior be tested to ensure they meet manufacturer specifications with regard to filtration rating. To learn more about High-Efficiency Particulate Arrestance (HEPA) air filter performance and limitations, please refer to

  - Newcomer, LaPuma & Northcross' Capture efficiency of portable high-efficiency air filtration devices used during building construction activities[9] and
  - Brandys, R. C. (2011). In-field test methods and reference standards for portable high efficiency air filtration (PHEAF) equipment. Hinsdale, IL: Occupational & Environmental Health Consulting Services, Inc.[10]

Keep in mind that when exhausting HEPA-filtered air into an occupied space, the HEPA filtration may not halt microbial and other VOCs or gases. Further engineering controls may be necessary.

- The users of critical barriers/containments should recognize possible failure points and the need for additional controls, containments and monitoring.
- Ensure adequate make-up air is available to maintain design pressure differential between interior boundaries in buildings.
- Suggested pressure differentials are ≥ 5.0 to 7.0 Pascals[4] with reference to the surrounding envelope or boundary. Ultimately, professional judgment is required, as circumstances may affect the ability to control and/or maintain design pressure differentials.
- Take into account risk-reduction measures to ensure the safety of the occupants who remain outside of the work area.

Air Filtration Devices (AFDs*)*

AFDs have been in use for many years with effective results and are commonly used throughout the industry. When configured appropriately, remediation companies use AFDs to help clean the air, as well as to provide pressure differentials across the envelope of the containment/structure. Various filter mechanisms help remove particles from the air.[11] There are benefits and limitations when using AFDs; those considerations should be identified prior to use.

The use of AFD devices will not result in 100% particle removal from the air in the work area. Many particles will likely not make it to the AFD for removal; many particles may settle out on various surfaces in the work area. AFDs are only part of the recommended cleaning process.

- AFD filter housings are prone to leakage caused by handling and/or improper filter installation. Ensure equipment is in good working condition and that the air filter media is seated properly. Caution should be taken to make sure that any device (including media) has been certified by the manufacturer as HEPA. Field testing[4] should also be done to validate performance of the equipment. We recommend testing the AFD using a laser particle counter and/or dioctyl phthalate (DoP) method.[10,11,12]
- The efficiency of HEPA filter performance cannot be established from historic testing and should be verified after transportation to the work site.
- AFDs have limited capture zones. Particles that are within a few inches/feet of the device inlet will be captured with a greater efficiency than suspended particles that are farther away. Stratification of air can also limit capture efficiency.[12(p988)] To help maximize AFD utility, locate the inlet as close as possible to the work area.
- When using AFDs to filter the air, consider using supplemental devices when possible to increase homogenous conditions for the purpose of particle suspension and thus helping to increase capture rates. Ensure proper engineering controls are in place to minimize "cross-contamination" concerns outside of the containment area. When operating air moving devices, care must be taken in dirty/contaminated environments to reduce re-aerosolization.

Remediation

- Techniques and controls that reduce and help capture dust aerosolization at the source are encouraged via dust suppression methods and local exhaust ventilation. To further clarify, the Surviving Mold panel recommends the use of local exhaust ventilation to help minimize cross-contamination of the nearby surfaces and air. Whenever possible, areas being cut/disturbed should be performed within the capture zone (1-3") of the vacuum inlet.
- Discoloration does not always indicate microbial growth. Sometimes discoloration may be the result of lignin and/or other organic materials or chemical reactions. Discoloration should be investigated further or accepted by the client.
    - For example, when a nail embedded in lumber gets wet, a chemical process can occur that results in dark staining. In this case, such staining is not necessarily microbial growth.
    - Some molds and other microorganisms also produce pigmented compounds that stain the surface on which the organism is growing. Irregular stains may be an indication of biological amplification or water damage. *Cladosporium* and other molds may cause black or black-blue stains on wood.
- When possible, avoid transporting contaminated items (bagged or otherwise) through unaffected areas.
- We recommend that floor protection be laid down from the contained entry chamber to the chosen entrances and exits. Tacky mats should also be used at the entries to these locations as a secondary dust control method. Work sites require professional judgment.

Re-Building Consideration

- When possible, we recommend leaving up any containment and/or critical barriers for the duration of the rebuild process to help minimize aerosolization of construction dust.

Antimicrobials/Pesticides

(*biocides, biostats, fungicides, fungistats, liquid sterilants, disinfectants, sanitizers, enzymes, and other compounds that "kill" or destroy or inhibit organisms*)

A number of antimicrobial, biocidal, fungicidal, enzymatic, and other products (some with unlisted proprietary ingredients) are sold and marketed with claims that they will kill, inactivate, eliminate, or otherwise destroy mold. According to the US Environmental Protection Agency (EPA),

> "…the purpose of mold remediation is to remove the mold to prevent human exposure and damage to building materials and furnishings. It is necessary to clean up mold contamination, not just to kill the mold. Dead mold is still allergenic [i.e., inflammatory], and some dead molds are potentially toxic." Particulates are the greatest carrier of compounds that cause not just allergy but innate immune activation.[2]

The preparers of this document have not found the use of products marketed specifically for eliminating mold to be effective[13] or beneficial, especially when used for medically important remediation. We support surface cleaning using a soap, detergent, or surfactant-based cleaner such as dish soap or detergent that is well tolerated by hypersensitive individuals occupying the structure. The methods for cleaning and use of cleaning agents will be further detailed in this document.

- Killing microorganisms does not eliminate the biological material that remains behind. This would include the spores, fragments, hyphae, and other residuals produced by microorganisms associated with water damage and their primary and secondary metabolites. Microorganisms can most effectively be removed by cleaning them from the environment.[14] This can be accomplished without killing or inactivating them.
- Microorganisms exist that produce spores with liquid-repelling, hydrophobic surfaces that resist penetration. The extended dwell times necessary in order to "kill" these microbes are not practical.
- Studies show the ineffectiveness of commonly used antimicrobials being applied in the indoor environment.[13,14,15,16,17]
- Most of the biomass contained within areas of microbial growth is already non-viable (dead). These non-viable particles may retain their harmful properties and need to be cleaned to remove them from the environment. Much of this biomass is made up of submicron-sized particles (nanoparticles) that may be even more dangerous when inhaled[18] because these particles bypass the body's defenses (mucus, cilia, coughing) and can be absorbed from the lung's alveoli directly into the blood stream.
- If some chemical agent were able to overcome the microbial defenses and kill the spores, there are concerns it would also be harmful to humans or animals — think lead and mercury-based paints and products that have now been outlawed.[19,20]
- In addition, products that leave residues may be environmentally affected by things like moisture and/or heat, which may alter the chemistry and result in potentially harmful exposures.
- There is no efficacy test method for addressing fungal ascospores in the presence of bacterial biofilms.[21]
- The introduction of chemicals designed to kill some types of mold has been shown to increase the cytotoxicity of the mold. The introduction of toxic chemicals can induce the production of secondary metabolites that are also toxic.[22]

- The use of antimicrobials may result in the development of resistant organisms. For example, the use of the antifungal benomyl in paint has resulted in the development of resistant fungal organisms.[23] The development of antibiotic resistance after antibiotic treatment is well documented.

There is no purpose or reason for attempting to kill or inactivate microorganisms. Microbial growth that has already occurred should be physically removed from the affected surfaces. If it has grown on a soft or porous item, the item should be discarded. Growth on hard surfaces should be prevented by keeping the material clean and dry. If there are no nutrients available, microorganisms will not grow. Microorganisms will not amplify if excessive moisture does not exist. Effective methods that do not require harmful or toxic chemicals and are proven to help remove excess levels of mold and other organisms (the biomass from water-damaged buildings) are discussed in more detail in other parts of this document.

We recommend that products be avoided that contain perfumes, fragrances, deodorizers, or chemicals that reduce the ability to recognize odors, or other methods that may mask odors or induce olfactory fatigue, or even lead to the dysfunction of taste. People with sensitivities frequently are unable to tolerate odorous or fragrant products. At the end of a water-damage remediation, the building should be clean, dry and free of mal-odor, because the biomass and residues have been physically removed and not because they have been covered up by the use of methods that prevent the odors from being detected.

Dry ice media blasting

Some remediation projects use abrasive techniques to physically remove microbial growth. Careful consideration regarding the use of these techniques is important when working with people with medically diagnosed conditions. The use of any blasting process and media should first be discussed with a knowledgeable Indoor Environmental Professional (IEP).

Media blasting is a technique used for hard-to-reach spaces and/or extensive amounts of microbial growth on exposed wood framing, masonry, and other durable materials where traditional remediation methods may not be an option.

One of the consequences of using abrasives is fine particulate generation. Such particulates are harder to remove and may limit the testing options to detect them. For example, fragmented fungal structures may not be identified using various laboratory analysis methods, including but not limited to culturing and microscopy.

Use of dry ice can create a risk of worker asphyxiation in confined spaces due to liberation of carbon dioxide (CO_2) and reduction in oxygen (O_2).

In order to minimize cross-contamination concerns and maintain safe working conditions, when media blasting techniques are used, extreme caution and attention to containment, barriers, and engineering controls are paramount, including local exhaust techniques that ventilate to the outdoors and appropriate fresh/make-up air.

Consider that the use of these media blasting techniques can result in the need for additional small particle cleaning efforts.

Misting versus fogging: cleaning versus killing

Misting and fogging are techniques that are more frequently being promoted, often inappropriately. The sciences of these techniques are often poorly understood by the user. The application is frequently misapplied.

The method of misting to help control airborne and surface particulates during remediation for dust suppression and clean-up purposes is discussed and supported in Section 12.1.7 (Misting) of the S520, which allows misting when used for this purpose but not for killing/destroying. Some manufacturers promote the ability of their "fogging" or "misting" products to "fumigate, kill, destroy, inactivate, render inert, or prevent reproduction" of microorganisms. This consensus body does not recommend considering any products that promote these techniques as part or whole of their fogging methods. There is a complicated science behind misting techniques. It is important to understand the scientific basics of how particles behave in order to successfully apply misting for fine particle removal (See Appendix A).

If misting is utilized, the following are important considerations:

- When executing any fogging, misting, or other aerosolizing techniques, ensure the manufacturer's process and that the user follows the principles of cleaning with physical removal discussed in this document. Always use appropriate PPE, procedures, and controls in accordance with the Safety Data Sheet as well as applicable regulations.
- The size of misting droplets should be between 50-100um.
- Droplets that are too large become a spray and settle too rapidly. Excess moisture must always be cleaned up immediately in order to prevent secondary damage.
- Temperature should be controlled. This is because at too low a temperature, droplets may freeze, and at too high a temperature, condensation ability decreases to a point where droplet size is less effective at settling.
- Relative humidity (Rh) should be at least 40% Rh to help facilitate the growth of droplet size and more quickly reach super saturation (101% Rh). Gravity helps rapidly settle these droplets, and the contaminants they contain, to the floor/surfaces so they can be physically removed by cleaning. Take care not to over-wet surfaces during this process.
- Cleaning is an important part of small particle remediation, as misting techniques alone do not remove the allergenic, toxigenic, inflammatory, infectious, carcinogenic, or other harmful properties of contaminants.
- Air velocity should be minimized to slow evaporation of the droplets while efforts to reach super saturation occur.
- Positive and negative air pressure differentials can cause misted liquid droplets to evaporate quicker, thus reducing overall coagulation cleaning effect.
- If large non-porous or semi-porous furniture or other personal possessions are left in the room, they should be pre-cleaned and protected from secondary damage during and after the misting process. Contents that can be easily moved should be emptied from the room where remediation is being performed. Care should be taken to prevent cross-contamination from transporting contaminated items into clean areas of the building.

HEPA vacuuming and final cleaning

Section 12.2.9 of the S520 provides an industry standard approach for cleaning surfaces; however, the S520 also requires that remediators "...select cleaning methods and products based on the specifics of the project…" This section takes a closer look at some of the more common cleaning

methods and products, as well as things to consider when selecting the optimal cleaning method when there are health-based concerns.

The following final cleaning methods are used for both buildings and personal property or contents. Please refer to Section 14 of the S520 to learn more about handling of contents.

HEPA VACUUMING

- HEPA vacuums are typically used to remove coarse particles/debris from surfaces while minimizing contaminants from being released back into the environment from the vacuum cleaner. HEPA vacuums should be used for initial surface cleaning (or prior to final small-particle cleaning methods) when visible debris or heavy amounts of dust are present, as dry vacuuming is better able to pick up larger particles.[9]
- Smaller particles may have adhesion forces that are stronger than the capture force generated by HEPA vacuums.[9] Therefore, where applicable, other methods for small particle removal are employed after vacuuming. According to the 2009 Centers for Disease Control (CDC) document Approaches to Safe Nanotechnology,

  "...Forces of attraction may make it difficult to entrain particles off surfaces with a vacuum cleaner. The electrostatic charge on particles will cause them to be attracted to oppositely charged surfaces and repelled by similarly charged surfaces. A similarly charged vacuum brush or tool may repel particles, making it difficult to capture the aerosol or even causing it to be further dispersed. Vigorous scrubbing with a vacuum brush or tool or even the friction from high flow rates of material or air on the vacuum hose can generate a charge".[24]

- It is imperative that procedures such as using microfiber cloths for damp and dry wiping follow HEPA vacuuming for small particulate cleaning.
- HEPA vacuum filter housings are prone to leakage caused by handling and/or improper filter installation. Ensure equipment is in good working condition and that the air filter media is seated properly. Caution should be taken to make sure that any device, including media, has been certified by the manufacturer as HEPA.
- HEPA filter performance efficiency cannot be established from historic testing and should be verified prior to entering the work site. Field testing[10] should also be done to validate performance of the equipment. If unable to validate performance, we recommend exhausting the vacuum canister to the outdoors, away from the public and to prevent re-entrainment into the building.
- Keep in mind that when exhausting HEPA-filtered air into an occupied space, the HEPA filtration may not halt microbial and other VOCs or gases. Further engineering controls may be necessary.
- Cracks and crevices, or hard to reach areas, may require additional cleaning efforts (e.g., use of synthetic ear swabs).

WIPING OF SURFACES

After HEPA vacuuming surfaces, adhered contaminant and fine particulate removal typically begins with damp wiping followed by dry wiping. In keeping with the best-practices of cleanroom cleaning techniques, wiping the surfaces involves multiple rounds.

Antimicrobials should not be used for this process unless a bloodborne pathogen[7] *(*Subpart Z - Toxic and Hazardous Substances, sections 1910.1000-1910.1450) or Category 3[3] loss exists. Any other environmental or exposure concerns should be reviewed with an experienced IEP.

Note to reader: If chemical air-scrubbing/washing techniques are used, the protocols may need to be adjusted subject to manufacturers' guidance and recommendations.

ROUGH SURFACES

- Rough surface wiping is often difficult or unfeasible using damp or dry-wiping techniques, due to the material snagging to the surfaces.
- Typically, mechanical cleaning methods (e.g., compressed air or HEPA vacuuming) are not recommended for final cleaning of smooth surfaces but may be employed, if deemed appropriate, to clean rough surfaces, along with using local exhaust ventilation. This method of cleaning should be performed before any damp-wiping occurs on other surfaces. When using compressed air, please follow OSHA 29 CFR 1910.242(b).[7]
- For rough or unfinished surfaces (e.g., concrete block, unfinished wood, particle board), HEPA vacuuming, or the use of compressed air followed by HEPA vacuuming, may be the most effective final cleaning technique.
- Because of the variation of surface porosities and potential micro-reservoirs, if the remediation company is unsure of how to approach cleaning a rough surface, they should consult with an experienced IEP.
- Another less desirable and controversial method to address rough surfaces is applying an appropriate encapsulant. Please consult with an IEP if this method is chosen.
- Cracks and crevices, or hard to reach areas, may require additional cleaning efforts, such as the use of synthetic cleaning swabs and/or extra HEPA vacuuming using a small nozzle to increase suction velocity mechanical agitation with compressed air or HEPA vacuuming close to it.

SMOOTH SURFACES

- Damp wiping involves using a suitable surfactant like soap or detergent, preferably with microfiber cloth (or other cloth that does not leave lint or fibers) with light to moderate wiping pressure to remove water and fat-soluble contaminants and remaining debris from surfaces.
- It is important to leave surfaces free of surfactants or cleaning agents, as such chemicals are able to create films that harbor contaminants and/or support microbial growth. Take care to ensure the surfactant does not contain fragrances or strong odors, as such products may increase chemical exposure complaints.
- More than one round of damp wiping may be required to effectively remove debris from surfaces. It is important not to reuse the same cloth or towel. Do not double-dip (i.e., do not dip a soiled cloth into the cleaning solution).
- Disposable clothes are recommended to minimize cross-contamination. However, if reusable cloths are used, they should be laundered following manufacturer recommendations with regard to temperature, duration, agitation, and other conditions.[25]
- The use of 5-10% ethanol (ethyl alcohol) may be used as a final wipe to help remove residual soaps or films that may remain on surfaces.

- Cracks and crevices, or hard to reach areas, may require additional cleaning efforts (e.g., use of synthetic ear swabs)
- Dry wiping follows once damp wiping is completed.
- Dry wiping involves using electrostatic dust cloths (e.g., dry and unscented or microfiber Swiffer®), wiping down surfaces using a light to medium wiping pressure. During this step, soil should not be observed on the cloth. Re-wiping surfaces is required if soil is seen on the cloth.
- One way to determine whether additional wiping is needed is to clean surfaces until no more soiling is observed on the cloth. Verification that cleaning solution residue has been removed may be accomplished by applying painter's tape to a clean, dry, smooth surface and observing if it adheres. If the tape does not stick to the surface, that could indicate cleaning solution residue or dirt remains. In addition, shining a bright flashlight at an angle and using a damp swab to look for an absence of stains on the swab may also help verify the level of cleanliness on surfaces.

We recommend these initial quality assurance measures should be documented to identify who performed them, the specific locations/areas that were examined, and the remediator should sign off on all work performed. Keep in mind that these QA efforts are intended only to guide the remediator's efforts and does not replace a Post-Remediation Verification (PRV*)* to be executed by a third-party IEP.

7. HVAC System

Heating Ventilation Air-Conditioning (HVAC) systems and cleaning efforts are addressed in Section 13 of the S520 and, among other things, include use of the National Air Duct Cleaners Association Assessment, Cleaning and Restoration (NADCA ACR)[26] document.

Proper design, installation, maintenance, and restoration of Heating, Ventilation and Air Conditioning systems is especially important for the health and wellbeing of those with medically important conditions associated with water damage and damp building conditions.

Parts of the system that are inherently affected by dampness or condensation tend to be the most likely areas that develop microbial growth. Condensation moisture develops when parts of the system are at or below the dew point temperature. If this moisture is not able to dry completely on a daily basis and nutrient materials or house dust gets damp or wet, then microbial organisms typically begin to grow. The system must be properly designed, installed and maintained so that moisture is effectively removed from and directed out of the home. In order for this to occur, the installation must be performed to manufacturers' specifications. Systems and materials used to install them should be constructed from materials that are not subject to damage from water, nor provide nutrients to support microbial growth if they become damp.

Properly designed and constructed mechanical systems will help keep the interior of the system clean so that nutrients do not deposit and build-up on surfaces or gaps in areas that will be inherently damp. Sealing of the ducts and properly installed air filter assemblies can also help prevent the system from dispersing contamination associated with water damage or damp building conditions from one part of the structure to another.

ADDITIONAL CONSIDERATIONS

- Duct cleaning should be performed with minimum air velocity (in all parts of the duct work, especially at bends or change in duct size) to create laminar flow. Use an anemometer inside of the ductwork to measure velocity. Please refer to section 4.3.2 & 4.5.5 of the Air Conditioning Contractors of America (ACCA) Standard 6[27] and section 4.5.1 of the NADCA ACR 2013 Standard[26] to learn more.
- When cleaning ductwork, the controlled use of HEPA filtered air at the end of each duct line as cleaning occurs helps push the particles to the HEPA filtered device that is creating negative air pressure. The use of negative air pressure controls within the ductwork during cleaning is essential. Avoid pulling contamination across the coil assembly.
- Antimicrobials should not be used. All of the reasons explained for avoiding antimicrobials elsewhere in this document apply to ductwork and HVAC systems. In addition, air movement and distribution can increase exposure to sensitive occupants. Please refer to sections 4.2.4 & 6.3 of the ACCA Standard 6 to learn more.[27]
- Challenges exist with cleaning internally lined ductwork or flex ducting when microbial growth exists. In these cases, the removal and replacement of ductwork is recommended. Removal and replacement are also recommended when microbial contamination is suspected. Microbial contamination refers to the existence of microbial materials (e.g., mold and bacteria and their cell-wall material and extrolites, such as mycotoxins, inflammagens, and alcohol).
- In-slab ductwork can be difficult or impossible to clean and frequently leads to issues that are unable to be resolved. If they are abandoned, they should be completely sealed. Filling them with concrete may be necessary to prevent further contamination development or migration.

8. Additional Challenges and Considerations

In all cases where found, replace “pan joist” or “building cavities” used as a supply or return air duct or returns with rigid metal ductwork. According to the 2018 International Energy Conservation Code[28], Section R403.3.5 (Mandatory), “Framing cavities cannot be used as ducts or plenums.” While R403.3.5 refers to new construction, it is the consensus of this committee that existing buildings should also follow this requirement.

Certain limitations and deviations are discussed in section 9.3.4 of the S520. Section 11 of the S520 expands upon these topics, including complexities, complications, and conflicts. The Consensus Panel supports these sections, and offers the following thoughts:

- Hidden reservoirs may be present that were not detected during pre-remediation or post-remediation assessments. Changes in environmental and building conditions can make it difficult to identify all significant microbial sources. It is important to consider ongoing assessments, especially when dealing with environmental exposure concerns, including potential sampling of suspect interstitial cavities. Additional non-intrusive tools, such as moisture meters and infra-red measurements, can help identify more recent water intrusions.
- The use of sealants and encapsulants is discouraged. In addition to the cautions and concerns identified in the S520-2015 Section 12.2.9, the following points are not highlighted and should be considered:

- Many environmentally sensitive occupants are unable to tolerate chemical exposures.
- Problems can occur from operating paint sprayers when using coatings that create inhalable particulates from aerosols. For this reason, we suggest brush or roll-on application.
- When applying sealants or encapsulants, some areas/intersections are inaccessible and, consequently, do not receive the application.

If the occupant/owner agrees to apply sealants or encapsulants, the decision and reasoning why should be documented in writing.

- Remediation companies should avoid offering health advice with respect to their work.
- In addition to what the S520 mentions in Section 7 (Remediator Qualifications), we recommend the following:
  - Remediators using this document should have a basic understanding of health risks related to what they are remediating as well as the client's exposure concerns in order to better understand the client's needs and expectations. Consider researching information on SurvivingMold.com.[29]
  - Please verify with all involved contractors and subcontractors that they have the required local, state, and/or federal licensure and appropriate safety measures, training, and implementation in place.

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11. Appendices

Appendix A: The science of fogging vs. misting

THE SCIENCE BEHIND MISTING

Using Fogging or Misting to Kill Mold and other micro-organisms is discouraged for all the reasons stated in the body of this consensus document. The use of Misting for fine particulate removal from the air can be effective and is permitted by the S520.

To be effective the use of misting requires a full understanding and application of scientific principles. Unfortunately, these principles are rarely applied in the field during remediation activities. This explanation of fogging versus misting is an attempt to explain the science and parameters necessary for misting for fine particulate removal to be effective.

Misting involves principles of physical sciences. To help understand the fundamentals, we relate misting to the concept of cloud and raindrop formation.

Clouds form when moist, warm rising air cools and expands in the atmosphere. The water vapor in the air condenses to form tiny water droplets, which are the basis of clouds. The vapor cools to the point where some of the water molecules "clump together" faster than they are torn apart by their thermal energy. Some of that invisible water vapor condenses to form visible cloud droplets or ice crystals.

Clouds are created when water vapor, an invisible gas, turns into liquid water droplets. These water droplets form on tiny particles, like dust, that float in the air.

The air can only hold a certain amount of water vapor, depending on the temperature and weight of the air – or atmospheric pressure – in a given area. The higher the temperature or atmospheric pressure, the more water vapor the air can hold. When a certain volume of air is holding all the water vapor it can hold, it is said to be "saturated." What happens if a saturated volume of air cools or the atmospheric pressure drops? The air is no longer able to hold all that water vapor. The excess amount changes from a gas into a liquid or solid (ice). The process of water changing from a gas (vapor) to a liquid (droplets) is called "condensation," and when gas changes directly into a solid, it is called "deposition." These two processes are how clouds form.[30]

Clouds form by various environmental forces typically involving warmer air that rises to areas of lower air pressure typically found at higher elevations. Eventually this lower pressure column of air allows for expansion, resulting in cooling. As the air cools, it reaches its saturation point. At this point, the moisture in the air can no longer remain in vapor form and begins to condense (super saturation) into "cloud droplets" or even very small ice crystals. This process usually starts with condensation nuclei and, through various coagulation mechanisms, these droplets continue to grow in size.[31,32,33]

> "To be effective, turbulent coagulation must help particles grow through the 10 to 40 micrometer gaps; condensation grows particles below this size and settling (kinematic) coagulation grows particles above it." [31]

Turbulent coagulation is part of the science behind misting. Intentional application of a misting process can allow for efficient collisions with airborne particles (e.g., microbial structures/fragments) of various sizes, which help capture otherwise difficult-to-remove airborne particles. The rate at which these smaller droplets/particles can grow in size depends on the conditions within the containment; however, simulations from the Riemer and Wexler Study[31]

indicate that, after 30 minutes using turbulent coagulation (box model simulations to predict development of clouds), 96% of the droplet mass studied was more than 100um in size.

We know from particle behavior in relatively quiescent environments that they will begin to readily deposit on surfaces, especially at sizes greater than 3 microns.[34] For example, in one study (Aerosolization of particulate (1➔3)-beta-D-glucan from moldy materials[35]) gravitational settling of an *Aspergillus versicolor* spore from a height of 1 meter and aerodynamic diameter of 2.4um*)* would take 96 minutes to settle out. For a *Stachybotrys chartarum* spore (aerodynamic diameter 4.6um), the settling rate was 26 minutes.

CONCERNS WITH DRY/THERMAL FOGGING

The main idea behind dry/thermal fogging is to fog a product (chemical solution) that is typically aerosolized at 25um droplets and smaller. Due to the decreasing capture efficiency (approaching zero) of smaller particles being able to collide, this suggests that fogging with smaller droplet sizes is less effective than misting with larger droplet sizes.[33] In a typical indoor environment (50% RH), smaller-sized water droplets can and will evaporate very quickly,[36] which calls into question the product's ability to coagulate with aerosolized particulates and to settle to the surfaces for cleaning/removal purposes.

Dry fogging uses smaller droplet size (10 to 40 μ) designed originally for flying insect control (mosquitoes), chemical deodorization, and other purposes. Dry fogging may increase chemical exposure complaints.

Thermal fogging typically involves the use of petrochemical and other semi-volatile organic compound (sVOC)-related chemicals. This method of fogging, which is commonly marketed to "kill" or "destroy" various microorganisms, is not an appropriate method for microbial remediation or cleaning with physical removal and may increase chemical exposure complaints.

Such fogging techniques are not "misting" and are not designed to settle out aerosolized particulates during remediation. This information supplements the general statements in the S520 (Section 12.1.7) that permit the use of misting but do not explain the necessary parameters for it to be effective.

ADDITIONAL CONSIDERATIONS

- Misting has been defined in established literature as using 50-100 um droplet sizes.[37]
- For misting to be effective in small particle removal from the air, there must be a balance between initial droplet size, humidity, air temperature, and air velocity. Studies indicate that particle sizes need to exceed 40um in diameter in order to more effectively settle with gravity.[31]
- If the droplet size is too small, particles will not be adequately enveloped, and therefore not captured as effectively with coagulation; additionally, the droplets will not settle with gravity because the droplets evaporate too quickly.

In order to be effective in removing mold and other micro-organisms and their associated particles from the air the process of Misting must control for temperature, humidity, air velocity, evaporation and droplet size as described in the body of this consensus statement.

Appendix B

POST REMEDIATION ASSESSMENT METHODS

Throughout this document we have deliberately excluded IEP assessment methods. It is this consensus body's intention to develop a separate document that addresses sampling and investigations.

While that document is intended to be more in-depth, the following resources and considerations provide an introduction that this panel of professionals supports:

The S520-2015 mentions Post-Remediation Evaluations (Section 12.2.11), and Post-Remediation Verification (Section 12.2.12*)*. This document also recommends the following visual and olfactory actions:

- The testing criteria of any IEP involved on a project should be explained to the client and remediator prior to the start of the project.
- Odors should not be present, whether microbial, chemical or product-based, in the containment or cleaning areas.
- Regarding an introduction to sampling methods, we recommend the following educational resources:
    - American Industrial Hygiene Association's Recognition, Evaluation, and Control of Indoor Mold (2008), Section 18.3 Measurement of Settled Dust) and Section 18.4 (Species Determination of Settled Dust)[38]

        Note: 18.4 does not readily promote the use of culturing to species level, however, we recommend analysis of mold to the species level for the following reasons:

    - If nothing cultures, it may be because the contractor used an antimicrobial product that may indicate antimicrobial material was left behind due to poor cleaning efforts.
    - While successful remediation/cleaning efforts may have been performed by the contractor, leaky buildings may allow for pathways into the containment area, resulting in incorrect assumptions of inadequate cleaning.
    - Supporting some of what is written in Section 18.4, when some undesirable species settle and dominate on the surface, then the best cleaning efforts may reduce the concentrations of the undesirable species, but those species will probably still dominate the surface sample.
    - It can be useful to identify the predominant species of mold present prior to remedial efforts ("diagnostic phase") in order to establish a baseline of what should be expected in any follow-up sampling.
    - Brandys, RC, & Brandys, GM. (2014). Post-remediation verification and clearance testing of mold and bacteria remediation projects: risk-based levels of cleanliness standards. Hinsdale, IL: Occupational & Environmental Health Consulting Services.[39]

