NATIONAL AIR DUCT CLEANERS ASSOCIATION

# ACR 2006

## Assessment, Cleaning and Restoration of HVAC Systems

The Industry Standard for HVAC Cleaning Professionals

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# Assessment, Cleaning, and Restoration of HVAC Systems

*An Industry Standard Developed by the National Air Duct Cleaners Association*

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Published by
NADCA National Air Duct Cleaners Association
1518 K Street, NW, Suite 503
Washington, DC 20005



Printed in the United States of America.

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# Assessment, Cleaning, and Restoration of HVAC Systems *ACR 2006*

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# Foreword

*Assessment, Cleaning, and Restoration of HVAC Systems* (ACR 2006) is an industry standard that has evolved from guidelines, industry standards of care, and research originating from the National Air Duct Cleaners Association (NADCA) along with other organizations dedicated to HVAC system hygiene, remediation and restoration. This standard establishes criteria for evaluating the cleanliness of HVAC system components, and for cleaning and restoring systems to a specific cleanliness level as described in Section 13.

ACR 2006 provides recommended inspection frequencies for HVAC systems. HVAC components that should be evaluated during inspections are described to assist users of this standard in determining when cleaning may be necessary.

In the assessment sections, ACR 2006 describes the areas of the HVAC system to be evaluated for contamination levels and the types of contaminants identified. Assessment information may then be used to select appropriate safeguards such as environmental engineering controls to protect the indoor environment during cleaning. The Guideline section of this document provides examples of several types of containment engineering strategies that may be employed in conjunction with an HVAC system cleaning project to control the migration of particulate, unwanted gasses, and vapors.

In the cleaning and restoration sections, ACR 2006 defines acceptable cleaning methods and criteria for cleaning tools and equipment. Cleaning encompasses the removal of contaminants in order to restore HVAC systems to a specific cleanliness level as described herein.

ACR 2006 addresses considerations for mold and biological contaminants and the cleaning of fiber glass insulation, duct liner and duct board. This document also provides requirements for creating service openings within HVAC systems; safety and health considerations for remediation workers, employees, and occupants; and procedures for monitoring cleaning projects as they progress.

The Standard also provides methods to verify HVAC system cleanliness. Three separate methods are defined and have been updated to address mold remediation clearance.

The term "HVAC system cleaning" is used exclusively throughout this document instead of the common term "air duct cleaning." The requirements of this document encompass the entire HVAC system and its components. To ensure optimum system performance and environmental conditions, the entire HVAC system should be maintained at the highest cleanliness levels possible and at an acceptable hygiene condition as described in this Standard.

**A Note Regarding Service Openings**
The National Air Duct Cleaners Association (NADCA) recognizes the need for service openings in HVAC system components, including air ducts, to facilitate inspection and/or cleaning. NADCA has expanded ACR 2006 to define minimum requirements for the proper construction and installation of service openings. This document should be cited in Project Specifications for HVAC system cleaning projects to insure proper access and closure of system components.

In nearly all HVAC system cleaning projects, it will be necessary to make new service openings in duct walls in order to insert cleaning and inspection equipment. The creation of service openings, and their subsequent closure, requires craftsmanship and professional skills. Where possible, access to duct interiors should be made by dismantling the ducts or through existing openings such as supply diffusers, return grilles, duct end caps, and existing service openings.

This Standard applies to the majority of HVAC systems, regardless of the type of duct construction. Service openings created in any type of system component must meet or exceed the requirements defined herein.

There are two general types of service openings: removable **duct access doors** and permanent closure **panels**. Duct access doors are designed so they can be re-opened without dismantling or altering the system. Permanent closure panels are pieces of HVAC system material that are sealed and/or fastened permanently upon closure of the service opening. Depending on the methods used to seal permanent closure panels, it may be possible to remove and re-install them. Permanent closure panels sealed with gasketing may be removed and re-installed; whereas those closure panels sealed with mastic or caulking should not be removed. If new service openings will be used in the future for inspection or cleaning, then removable duct access doors may be most appropriate.

The location and size of new service openings is heavily dependent upon the equipment and methodologies the HVAC system cleaning contractor will use in the project. However, there are certain strategic locations in most systems where service openings are made to facilitate inspection. Visual inspection of interior HVAC system surfaces is required as noted in this Standard.

The most common locations for service openings in air ducts include:

- Adjacent to turning vanes
- Adjacent to dampers (balancing, fire, control, back draft, splitter, etc.)
- Mixing & VAV boxes
- Adjacent to in-duct electric heat strips
- Duct transitions, offsets, and changes of direction
- Adjacent to heating, reheat, & cooling coils
- Adjacent to all other in-duct mechanical components & sensors

Each of these locations may require one or more service openings to properly access the ducts for cleaning and inspection. The tools used in the installation of the new service openings should be industry-specific for the type(s) of duct material and construction techniques commonly found in HVAC systems. Proper installation of new service openings is dependent on the use of the right tool(s) by trained personnel. Nothing in this Standard is intended to prevent the use of new methods, materials, or technologies in the installation and closure of service openings, provided that they meet the requirements prescribed by this Standard.

Poorly constructed service openings may have a negative impact on the HVAC system. An air duct system, when improperly altered, may compromise the system's structural integrity and fire-rating integrity. Improperly installed service openings may act as a site for duct leakage. An improperly created or sealed service opening may affect indoor air quality by serving as a conduit that can expose both the HVAC system and the indoor environment to contaminants. These potential threats to the safety of the building and its occupants are just two of the reasons for this Standard.

In some areas, the creation of a service opening in an HVAC system may require special licensure from the state or locality. Most state construction industries are regulated by a licensing board or commission authorized by the state government, and such organizations should be contacted directly for information about a particular state's requirements.

This Standard includes a new chapter in the appendix titled *Guidelines for Constructing Service Openings in HVAC Systems*. The information provided in this chapter is intended as a guideline to assist in the further understanding of HVAC service system opening construction methods, but its contents are not considered requirements under this Standard unless specified below.

It is highly recommended users of this document consult applicable federal, state and local laws and regulations. NADCA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws and this document must never be construed as doing so. The most stringent requirements of this Standard and applicable federal, state, and local regulation must apply to the assessment, cleaning, or restoration of HVAC systems. The disclaimer at the conclusion of this document provides additional important information regarding use of this standard.

# Assessment, Cleaning, and Restoration of HVAC Systems

# *ACR 2006*

## Introduction

Maintaining clean heating, ventilation and air-conditioning (HVAC) systems is an important part of sustaining acceptable indoor air quality (IAQ). When an HVAC system is a source of contaminants introduced into occupied spaces, properly performed system cleaning services should take place to reduce or eliminate contaminant introduction.

Contaminants in HVAC systems may take many forms. Common contaminants include dust particles, active bacterial or fungal growth, debris from rusted HVAC components, man-made vitreous fibers, mold spores, and other items.

Experience has shown that very few (if any) HVAC systems are free of all particulate. In fact, particle deposition on component surfaces starts before the HVAC system is even installed. Airborne particles in factory settings and assembly areas are likely to settle on air-handling components and fiber glass insulation, as well as adhere to the surface of metal components.

The original installation process will subject the HVAC system to even more contamination. Construction sites contain a significant amount of airborne concrete dust, gypsum dust, sand particles, biological particulate aerosols and many other airborne contaminants in the ambient air. These particles often settle on or within the HVAC system during construction.

After the HVAC system is installed and its operation begins, the particulate accumulation process continues throughout the life of the system. Poor design, installation and maintenance practices, low-efficiency air filtration, air flow bypass, inadequate or infrequent preventative maintenance practices, humid conditions, and many other factors will result in contaminated HVAC systems. HVAC systems may also serve to transport and redistribute unwanted particles from other sources in the building.

HVAC cleaning services have been available since the early 1900s. However, it was not until the 1970s that growing public concern for better IAQ led to an understanding of the importance of cleaning HVAC system components. Public awareness has increased ever since. Greater demand for HVAC cleaning resulted in dramatic growth for the HVAC system cleaning industry both for firms offering service, as well as those providing research and knowledge of HVAC system cleaning and its impact on indoor air quality and system performance. This ultimately led to the creation of industry standards, training and certification programs for HVAC system cleaning professionals.

ACR 2006 is the fourth edition of NADCA's standard for HVAC system cleaning. The first edition, NADCA Standard 1992-01, raised the performance bar for the industry by establishing the first method to verify post-cleaning cleanliness levels. The second edition, ACR 2002, built on the principles established in NADCA Standard 1992-01, but included many additional provisions for evaluating cleanliness before cleaning as well as requirements for how to perform cleaning services.

ACR 2005, the third edition, went further than any previous NADCA standard. It covered the same essential elements of assessment and cleaning detailed in the previous documents and also provides more detailed requirements for managing HVAC system cleaning projects, including clearly defined conditions that require cleaning. ACR 2005 was revised such that its requirements were in accordance with the latest standard for mold remediation published by the Institute of Inspection, Cleaning and Restoration Certification (IICRC), S520 - *Standard and Reference Guide for Professional Mold Remediation*. By working in cooperation with representatives from IICRC and other industry organizations to update the ACR standard, the 2005 edition was a standard that could be utilized not only as a standard for professional HVAC system cleaning contractors, but also as a comprehensive reference source for consumers, facility administrators, engineers, mold restoration contractors, general contractors, architects, or HVAC project design consultants.

ACR 2005 was written for commercial, industrial, healthcare, marine and residential applications. The Standard represented NADCA’s continued commitment to being the HVAC cleaning industry’s authoritative source for information related to HVAC system cleaning and restoration. ACR 2005 reflected a national and international collaboration of indoor environmental professionals, HVAC professionals, remediation, restoration and cleaning organizations all working together to create a document that was globally relevant in today’s society.

The fourth edition, ACR 2006, incorporates everything from ACR 2005, and includes an extensive protocol for cleaning coils. In addition, *Standard 05, Requirements for the Installation of Service Openings in HVAC Systems*, has been incorporated into ACR 2006. The result is a comprehensive standard that goes beyond previous editions to provide for superior HVAC system cleaning and restoration.

## 1 General

### 1.1 Scope

This standard defines procedures for assessing the cleanliness of HVAC systems and for determining when cleaning is required.

This standard sets acceptable criteria for the safe and effective cleaning and restoration of HVAC systems and components. It also defines environmental engineering principles necessary to control the migration of HVAC system particulate.

This standard provides test methods for verifying HVAC component cleanliness upon the completion of a cleaning project. This standard defines procedures necessary to allow HVAC system cleaning work to be performed in accordance with the requirements of IICRC S520, *Standard and Reference Guide for Professional Mold Remediation*.

The requirements set forth in this document address cleaning, building use, contaminant type, worker and occupant health and safety, and project monitoring.

This standard identifies construction methods and material performance criteria for the safe and effective creation and installation of new service openings used to facilitate the inspection and cleaning of HVAC systems.

### 1.2 Purpose

It is the intent of this document to provide consumers and specifiers of HVAC system cleaning and restoration services with information needed to help ensure that cleaning is performed to acceptable standards and in such a manner that the services contribute to improved system cleanliness and/or system performance.

This standard also defines the requirements necessary to construct and install service openings in HVAC systems.

### 1.3 Application

ACR 2006 provides standards and guidance for industry professionals, HVAC cleaning and restoration service providers, building owners and others who manage HVAC systems.

The requirements of this standard apply to all classifications of buildings, except as otherwise specified herein.

## 2 Definitions

Abrasion: A surface loss of material due to friction.

Access: The ability to gain entry to the interior of the air duct or HVAC component.

Access Door: Fabricated metal barrier (hatch) by which a service opening is accessed or closed.

Adhered Substance: A material, such as mastic, that is not removable by direct contact vacuuming.

ACGIH: American Conference of Governmental Industrial Hygienists.

Adhered Particulate: Any material not intended or designed to be present in an HVAC system, and which must be dislodged in order to be removed.

Aerosols: Solid or liquid airborne particles.

AIHA: American Industrial Hygiene Association.

Air Duct: A passageway for distribution and extraction of air, excluding plenums not installed in accordance with SMACNA Standards (See *ASHRAE Terminology of Heating, Ventilation, Air Conditioning & Refrigeration*, 1991).

Air Duct Covering: Materials such as insulation and banding used to cover the external surface of a duct.

Air Duct Lining: Generally refers to fiber glass or other matting affixed to the interior surfaces of the air ducts for thermal insulation and noise attenuation.

Air Filtration Device (AFD): A portable or transportable, self-contained blower assembly designed to move a defined volume of air equipped with one or more stages of particulate filtration. Depending on the mode of use, an AFD that filters (usually HEPA) and re-circulates air is referred to as an "air scrubber." One that filters air and creates negative pressure is referred to as a "negative air machine."

Air-handling Unit (AHU): A packaged assembly, usually connected to ductwork, that moves air and may also clean and condition the air.

> Central-station Air-handling Unit: factory-made, encased assembly consisting of the fan or fans and other necessary equipment, that perform one or more of the functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air; does not include a heating or cooling source.
>
> Cooling-heating Unit: unit that includes means for cooling and heating, and which may also include means for other air-handling unit functions.

Cooling Unit: unit that includes means for cooling and which may also include means for other air-handling unit functions.

Heating unit: unit that includes means for heating, and which may also include means for other air-handling unit functions.

Make-up air unit: factory-assembled fan-heater or cooling/dehumidifying unit that supplies tempered fresh air to replace air that is exhausted. Centrifugal or axial fans are used with direct gas-fired, electric, or water heater sections.

Ventilating unit: unit with means to provide ventilation, and which may also include means for other air-handling unit functions (See ASHRAE *Terminology of Heating, Ventilating, Air Conditioning, and Refrigeration*, 1991).

Air Scrubber: An air filtration device (AFD) using HEPA filtration configured to re-circulate air within a defined space.

Air Sweeping: A process that uses a pressurized air source combined with either handheld blowguns or a hose with a remote nozzle attachment to move particulate and debris within an HVAC system during cleaning.

ASCS: Air Systems Cleaning Specialist. The ASCS designation is awarded by NADCA to industry professionals who satisfactorily complete a written certification examination testing knowledge of HVAC systems, cleaning standards and best practices.

Ambient Air Cleaning: The process of removing particulate from indoor air outside of the HVAC system.

Antimicrobial: Describes an agent that kills or inactivates microorganisms or suppresses their growth (See ASTM E35.15)

Antimicrobial Surface Treatments: Chemical or physical agent applied to, or incorporated into materials that suppresses microbial growth.

Assessment: A comprehensive review and evaluation of the HVAC system, or representative portions thereof, to make a preliminary determination of which general forms of contamination are present and to document the overall system cleanliness level.

ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

ASTM International: American Society for Testing and Materials.

Bioaerosols: Airborne particles of biological origin.

Biological Contaminants: Bacteria, fungi (mold and mildew), spores, viruses, animal dander, mites, insects, pollen, and the by-products of these elements.

Cleaning: The removal of visible particulate and biologicals to a level defined within this document.

Closure: (1) An access door or panel installed on the air duct or air-handling unit to create a permanent seal. (2) Device or material used in closing a service opening.

Closure Panel: Sheet metal, or other appropriate material used for permanently closing a service opening.

Coatings: See "Surface Treatments."

Coils: Devices inside an HVAC system that temper and/or dehumidify the air handled by the HVAC system. These include heat exchangers with or without extended surfaces through which water, ethylene glycol solution, brine, volatile refrigerant, or steam is circulated for the purpose of total cooling (sensible cooling plus latent cooling) or sensible heating of a forced-circulation air stream (See ASHRAE 33-78 and ARI 410-91).

Collection Device: A HEPA-filtered machine designed primarily to collect debris, filter particulate and discharge air back to the indoor environment, or a fan driven non-HEPA-filtered machine that is designed to collect debris, and then filter particulate while discharging the air outside the building envelope.

Conditions: For the purpose of this standard, Conditions 1, 2, and 3 are defined for indoor environments relative to mold. Definitions for each Condition are as follows:

Condition 1 (normal ecology): An indoor environment that may have settled spores, fungal fragments or traces of actual growth whose identity, location and quantity is reflective of a normal fungal ecology for an indoor environment (See IICRC S520).

Condition 2 (settled spores and trace growth): An indoor environment, which is primarily contaminated with settled spores that were dispersed directly or indirectly from a Condition 3 area, and which may have traces of actual growth (See IICRC S520).

Condition 3 (actual growth): An indoor environment contaminated with the presence of actual mold growth and associated spores. Actual growth includes growth that is active or dormant, visible or hidden (See IICRC S520).

Constant Air Volume System: An air-handling system involving a continuous level of airflow.

Contact Vacuum: A Collection Device, usually portable, that uses a nylon brush nozzle attached to the end of its inlet air hose. The brush head is applied directly to a surface for cleaning.

Containment Area: An engineered space within a work area designed to control the migration of contaminants to adjacent areas during assessment or cleaning procedures.

Contaminant: Any substance not intended to be present that is located within the HVAC system.

Converging 45 Degree Cut: Applies to the angle of the cut when removing a section of ductboard to create an opening. Provides for resealable fit when re-installing the section for closure (sometimes referred to as a "pumpkin cut").

Crossbreak: Diagonal bends made in metal panels to increase rigidity and decrease flexibility.

Debris: Non-adhered substances not intended to be present within the HVAC system.

DOP Testing: The percentage removal of 0.3 micrometer particles of dioctylphthalate (DOP) or equivalent used to rate high-efficiency air filters, those with efficiencies above 98%.

Double Wall Duct: Sheet metal duct usually constructed with an inner perforated liner sandwiching fibrous glass insulation.

Duct Access Door: Fabricated metal barrier (hatch) by which a service opening is accessed or closed. Designed for permanent installation. May be available pre-fabricated in a variety of sizes and configurations. Most utilize cam locks for securing the removable door from the permanently installed doorframe. Types of Duct Access Doors are listed below:

Flush Mount - fabricated door and door frame which extends into the duct and is externally flush with the outside duct wall.

Surface Mount - fabricated door and door frame which extends out from the surface of the outside duct wall.

Hinged - fabricated door and doorframe attached together with a hinge.

Sandwich - two-part closure device in which the two sides are mechanically fastened together on both sides of the duct wall at the perimeter of the service opening.

Spin Door - round access door and door frame installed by spinning the door frame into a round opening.

Ductwork: A system of passageways for distribution and extraction of air, excluding plenums not installed in accordance with SMACNA Standards (See *ASHRAE Terminology of Heating, Ventilation, Air Conditioning & Refrigeration*, 1991).

EPA: United States Environmental Protection Agency.

Flame Spread Index: The Flame Spread Index refers to the sustained combustion classification of a material as listed in NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

Flange: Outer rim of an access door frame provided to attach the frame to the duct.

HEPA: High Efficiency Particulate Air. To be called a true HEPA filter, or certified HEPA filter the filter must have a documented filtration efficiency of 99.97% at 0.3 micron-sized particles.

Highly Recommended: When the term *highly recommended* is used in this document, it means the practice or procedure is a component of the accepted "standard of care" to be followed, though not mandatory by regulatory requirement.

HVAC System: The heating, ventilation, and air conditioning (HVAC) system includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning, and ventilation system from the points where the air enters the system to the points where the air is discharged from the system. The return air grilles, return air ducts to the air-handling unit (AHU), the interior surfaces of the AHU, mixing box, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housing, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, reheat coils, and supply diffusers are all considered part of the HVAC system. The HVAC system may also include other components such as dedicated exhaust and ventilation components and make-up air systems.

IAQA: Indoor Air Quality Association.

Indoor Environmental Professional (IEP): An individual who is qualified by education, training and experience to perform an assessment of the fungal ecology of property, systems and contents at the job site, create a sampling strategy, sample the indoor environment, interpret laboratory data, determine Condition 1, 2 and 3 status for the purpose of establishing a scope of work and verify the return of the fungal ecology to a Condition 1 status (See IICRC S520).

Inspection: A gathering of information for use in making determinations and assessments.

IKECA: International Kitchen Exhaust Cleaning Association.

Laser Particle Counter: Sophisticated instruments for measuring particle concentrations down to the sub-micron level.

MERV: Minimum Efficiency Reporting Value.

Mastic: Material used to caulk, seal, or cement gaps and cracks in air duct connections and joints.

Mechanical Agitation Device: A tool used to dislodge or move contaminants and debris within the HVAC system.

Mechanical Cleaning: Physical removal of contaminants and debris not intended to be present from internal HVAC system surfaces.

Mechanically Fasten: To affix two or more objects together through the use of screws, clamps, locks, or straps. (Contrast with mastic or tape.)

Microbiocide: Chemical or physical agent that kills microorganisms (ASTM E35.15)

Mold Contaminated: The presence of indoor mold growth and/or mold spores, whose identity, location and amplification are not reflective of a normal fungal ecology for an indoor environment, and which may produce adverse health effects and cause damage to materials, and adversely affect the operation or function of building systems.

MSDS: Material Safety Data Sheet.

Must: When the term *must* is used in this document, it means that the practice or procedure is mandatory due to natural law or regulatory requirements, including occupational, public health and other relevant regulations, and is therefore a component of the accepted “standard of care” to be followed.

NFPA: National Fire Protection Association.

Negative Air Machine: A HEPA-filtered air filtration device designed primarily for collecting particulate and limiting particulate migration while controlling workspace pressure differentials. These machines may or may not be ducted outside the building envelope.

Non-adhered Substance: Any material not intended or designed to be present in an HVAC system, and which can be removed by contact vacuuming.

Non-porous HVAC System Surface: Any surface of the HVAC system in contact with the air stream that cannot be penetrated by water or air, such as sheet metal, aluminum foil, or polymetric film used to line flexible duct.

NAIMA: North American Insulation Manufacturers Association.

OSHA: United States Occupational Safety and Health Administration.

Panel: (1) Fabricated section of metal making up the structural shell of a piece of mechanical equipment. (2) Patch of sheet metal used for closing a service opening.

Particulate: Any non-adhered substance present in the HVAC system that can be removed by contact vacuuming.

Permanent: The life of the system.

Plastic Plug: Round polyethylene cap used to close 1"-3" openings in sheet metal duct. (Note: the materials used in the manufacture of these devices often exceed the indices for flame spread and smoke spread as set forth in NFPA 90A & 90B).

Porous HVAC System Surface: Any surface of the HVAC system in contact with the air stream that is capable of penetration by either water or air. Examples include fiber glass duct liner, fiber glass duct board, wood, and concrete.

Preliminary Determination: A conclusion drawn from the collection, analysis and summary of information obtained during an initial inspection and evaluation to identify areas of moisture intrusion and actual or potential mold growth (IICRC S520).

Pressure Drop: (1) Loss in pressure, as from one end of a refrigerant line to the other, from friction, static, heat, etc.; (2) Difference in pressure between two points in a flow system, usually caused by frictional resistance to fluid flow in a conduit, filter or other flow system (See

ASHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration, 1991).

Recommended: When the term *recommended* is used in this document, it means the practice or procedure is advised or suggested.

Regulated Hazardous Materials: This includes any substances such as asbestos or lead that are regulated under applicable national, state and local regulations.

Requirement: Mandatory practice for compliance with this standard.

Restoration: To bring back to, or put back into, a former or original state.

Seal: To make secure against leakage by a fastener, coating, or filler.

Sealant: A fastener, coating, or filler used to seal against air leakage.

Service Panel: Fabricated piece of metal making up a part of the structural shell of a piece of mechanical equipment. Often allows for entry to service equipment.

Shall: (See “Must”)

Shiplap Tool: Specialized cutting tool for fabricating fibrous glass board.

Should: Indicates a recommendation, or that which is advised by this standard, but is not mandatory (See “Highly Recommended”).

Sleeve Collar: Fabricated door frame extension used to install typical surface-mount access doors in fibrous glass ductboard.

SMACNA: Sheet Metal and Air Conditioning Contractors’ National Association.

Source Removal: See “Mechanical Cleaning.”

Stain: A remaining discoloration on the HVAC system surface after contact vacuuming, which cannot be removed.

Standard of Care: Practices common to reasonably prudent members of the trade who are recognized in the industry as qualified and competent.

Surface Comparison Testing: A test used to determine the cleanliness of both non-porous (metal) and porous (fiber glass) HVAC component surfaces (See Section 13.2 of this standard).

Surface Treatment (non-antimicrobial): Coating or treatment designed to repair surface defects or modify surface characteristics

TVOC: Total volatile organic compounds.

Thermal Acoustic Materials: HVAC insulation materials designed for sound and temperature control.

UL: Underwriters Laboratories, Inc.

Vacuum Collection Equipment: See “Collection Device.”

Visibly Clean: A condition in which the interior surfaces of the HVAC system are free of non-adhered substances and debris.

Visual Inspection: Visual examination with the naked eye of the cleanliness of the HVAC system.

Wet Process Cleaning: Any method of mechanical cleaning of HVAC components that utilizes water and/or liquid chemicals as part of the process (i.e. power washing, steam cleaning, hand washing).

## 3 Determining the Need for HVAC System Cleaning and Restoration

It is highly recommended that HVAC systems be cleaned when an HVAC cleanliness inspection indicates that the system is contaminated with a significant accumulation of particulate or if microbial contamination conditions have reached either Condition 2 or Condition 3. If the preliminary inspection shows that HVAC system performance is compromised due to contamination build-up, cleaning is highly recommended.

Often HVAC system components collect significant amounts of debris and particulate during construction activities within a building. It is highly recommended that newly installed HVAC systems or HVAC systems undergoing renovation be verified clean, and protected before the system is permitted to operate. It is highly recommended that consistent HVAC system inspections be part of a building's overall indoor air quality management program.

### 3.1 HVAC Cleanliness Inspection Schedule

HVAC systems should be routinely inspected for cleanliness by visual means. Table 1 provides a recommended inspection schedule for major HVAC components within different building use classifications.

The inspection intervals specified in Table 1 are minimum recommendations. The need for more frequent cleanliness inspections is subject to numerous environmental, mechanical and human factors. Geographic regions with climates having higher humidity, for example, will warrant HVAC system inspections on a more frequent basis, due to the increased potential for microbial amplification.

If the inspection of an HVAC unit's air-handling components reveals contamination, then supply and return ductwork must be inspected during that same inspection time rather than in accordance with the intervals specified in Table 1.

**Table 1**
**HVAC Cleanliness Inspection Schedule**
**(Recommended Intervals)**

| Building Use Classification (See Section 4.1) | Air-handling Unit | Supply ductwork | Return ductwork / Exhaust |
|---|---|---|---|
| Industrial | 1 year | 1 year | 1 year |
| Residential | 1 year | 2 years | 2 years |
| Light Commercial | 1 year | 2 years | 2 years |
| Commercial | 1 year | 2 years | 2 years |
| Healthcare | 1 year | 1 year | 1 year |
| Marine | 1 year | 2 years | 2 years |

### 3.2 HVAC System Component Inspections

The cleanliness inspection should include air-handling units and representative areas of the HVAC system components and ductwork. In HVAC systems that include multiple air-handling units, a representative sample of the units should be inspected. If the inspection is being conducted as part of a mold remediation project in accordance with IICRC Standard S520, then all components of the HVAC system must be inspected.

The cleanliness inspection must be conducted without negatively impacting the indoor environment through excessive disruption of settled dust, microbial amplification or other debris. In cases where mold contamination is suspected, and/or in sensitive environments where even small amounts of contaminant may be of concern, environmental engineering control measures must be implemented and the services of an Indoor Environmental Professional (IEP) are highly recommended to determine the overall impact on the indoor environment.

#### 3.2.1 AHU Inspections

The air-handling unit (AHU) cleanliness inspection should consider all components within the unit, including filters and air bypass, heating and cooling coils, condensate pans, condensate drain lines, humidification systems, acoustic insulation, fans and fan compartments, dampers, door gaskets and general unit integrity.

### 3.2.2 Supply Duct Inspections

The supply duct cleanliness inspection should consider a representative portion of supply system components including, but not limited to, supply ducts, controls, mixing/ control boxes, reheat coils and other internal components.

### 3.2.3 Return Duct Inspections

The return duct cleanliness inspection should consider a representative portion of return system components including, but not limited to, return ducts, dampers, return plenums, make-up air plenums and grilles.

## 3.3 Inspecting for Mold Contamination

It is highly recommended the HVAC system cleanliness inspection include a preliminary determination of the level of mold contamination (Condition 1, 2 or 3) and other biological activity. The inspection should evaluate the air-handling unit, humidifier and other representative system components.

HVAC systems should be inspected at least twice annually when they include supplemental humidification or when they are located within a hot and humid climate.

### 3.3.1 Preliminary Determination for Mold

After the initial HVAC system component inspection, a preliminary determination must be made by the person performing the inspection regarding potential mold contamination. Making a determination involves the collection, analysis and summary of information to identify areas of moisture accumulation and potential mold growth. A preliminary determination may indicate the need for further assessment by an IEP and/or other appropriate professionals (See IICRC S520).

### 3.3.2 Surface Mold Growth

If the preliminary determination indicates a small, isolated area of mold growth on a surface layer of condensation on painted walls or non-porous surfaces, and mold growth has not occurred in concealed areas, the use of an IEP generally is not necessary and the mold usually can be removed as part of a regular HVAC maintenance program (See IICRC S520).

### 3.3.3 Limited Mold Growth

If the preliminary determination indicates a limited amount of visible mold confined to a specific area, (e.g. a small area of a mechanical system that is not in the path of the major air circulation system of the structure), the use of an IEP may or may not be necessary and the restorer or remediator's professional judgment is needed in making appropriate recommendations (See IICRC S520).

### 3.3.4 Extensive Mold Growth

If the preliminary determination indicates extensive mold growth that is visible, hidden or suspected as a result of a chronic or lingering moisture problem, it is highly recommended that the extent of microbial growth or Condition (1-3) to which areas of the HVAC system are mold-contaminated be determined. It is highly recommended that this determination be made by a thorough assessment performed by an IEP before starting remediation. However, in some circumstances where Condition 3 contamination has been determined and the entire HVAC system is located within the contaminated area, or when the scope of work can be determined without sampling, testing or independent IEP inspection, then engagement of an IEP during the preliminary determination process may not be necessary. Further, some loss mitigation services (e.g., water damage restoration) may be initiated before or while assessing conditions and/or remediation processes (See IICRC S520).

If mold or biological sampling is performed, it must be in accordance with established industry standards and guidelines.

## 3.4 HVAC Inspector Qualifications

It is highly recommended that a qualified HVAC inspector be used to determine the preliminary state of HVAC system cleanliness. At minimum, such personnel should have a verifiable working knowledge of basic HVAC system design, fundamental HVAC engineering practices, current industry HVAC cleaning and restoration techniques, and applicable industry standards. Individuals who are inspecting for microbial contamination should be qualified to determine Conditions 1, 2 and 3.

## 3.5 Conditions Requiring Cleaning

It is highly recommended HVAC system cleaning be performed when any of the following conditions are found during the HVAC Cleanliness Inspection.

### 3.5.1 HVAC System Contamination

If significant accumulations of contaminants or debris are visually observed within the HVAC system, then cleaning is necessary. Likewise, if evidence of active fungal colonization is visually observed or confirmed by analytical methods, then cleaning is required. If the system has been confirmed by an IEP to be at Condition

2 or Condition 3 status then the system must be cleaned.

If the HVAC system discharges visible particulate into the occupied space, or a contribution of airborne particles from the HVAC system into the indoor ambient air is confirmed, then cleaning is highly recommended.

See the guideline to this standard for discussion of the Particle Profiling (PP) procedure, which may be used to confirm if non-visible contaminants are being introduced into the indoor environment via the HVAC system.

3.5.2 Compromised Performance

Cleaning is highly recommended for heat exchange coils, cooling coils, air flow control devices, filtration devices, and air-handling equipment determined to have restrictions, blockages, or contamination deposits that may cause system performance inefficiencies, air flow degradation, or that may significantly affect the design intent of the HVAC system.

3.5.3 Indoor Air Quality Management

Indoor air quality management plans that include periodic cleaning and maintenance are highly recommended to minimize recurring contamination within HVAC systems. It is highly recommended that special consideration be given to buildings or residences with sensitive populations such as individuals with compromised immune systems, and specialized environments or buildings with sensitive building contents or critical processes.

3.6 HVAC System Engineering Assessment

It is highly recommended that in addition to an HVAC cleanliness inspection, a complete engineering assessment of the design and condition of the entire HVAC system be considered depending on the conditions that exist in the project. This is especially important if temperature and/or relative humidity conditions cannot be maintained within the spaces in compliance with the requirements of ASHRAE Standards 62.1 or 62.2; if temperatures, relative humidity or airflow varies between different areas of the building; or, if the mechanical components are not in good condition and/or repair. There are four primary reasons this HVAC System Engineering Assessment is important to the success of a remediation project:

- The original system design may not have been adequate to maintain optimal indoor environmental (or psychrometric) conditions in the building;
- Expansions, renovations or changes of use of the original space may have rendered the HVAC system design inadequate for the current needs of the building and its occupants;
- The system may not have been installed as designed, or commissioned so as to assure that its operation met the design objectives; and
- Mechanical deterioration and/or physical damage to system components may have degraded their performance to the point where they cannot provide the necessary level of air flow or capacity.

The description of what constitutes an adequate engineering evaluation of HVAC system condition and capacity is beyond the scope of this standard. It is recommended that qualified engineering professionals or HVAC contractors be consulted for such an evaluation.

## 4 Project Evaluation and Recommendation

When contamination is identified or other criteria triggering cleaning in Section 3 are met, it is highly recommended a project evaluation take place prior to initiating cleaning work. The project evaluation includes three steps: 1) determining the building usage by classification; 2) identifying the type of contamination present in the HVAC system; and 3) conducting an indoor environmental impact survey.

The HVAC contamination type and the environmental impact survey must include a visual evaluation of representative sections of the HVAC components and the occupied spaces served by the HVAC system. This evaluation serves to visually inspect conditions within the HVAC system and verify the overall physical integrity of system components and surfaces.

Information collected from the project evaluation should be used to define the scope of the cleaning and restoration project, cleaning techniques to be employed, the environmental engineering controls required for the workspace, and any unique project requirements.

4.1 Building Use Classification

Classifying the type of building and its uses is an important part of project evaluation. Cleaning methods, project specifications, environmental engineering controls, and cleanliness verification methods may vary among different buildings. Building classifications are listed in Sections 4.1.1 to 4.1.8 of this standard. If the HVAC system restoration project is being conducted as part of a larger mold remediation project, it is recommended the building's usage classification be determined by an IEP to assess the overall impact of the contamination present and the corrective cleaning actions specified to remediate the contamination.

#### 4.1.1 Industrial

Buildings classified as *industrial use* include any facility housing the manufacture, fabrication, processing, handling, and storage of materials or products.

#### 4.1.2 Residential

Buildings classified as *residential use* include stand-alone homes, apartment buildings, and condominiums where people reside.

#### 4.1.3 Light Commercial

Buildings classified as *light commercial use* include space with a constant volume HVAC system up to, and including, 10 tons cooling or equivalent heating capacity, or 4000 CFM nominal air flow, whichever is greater.

#### 4.1.4 Commercial

Buildings classified as *commercial use* include space with an HVAC system of greater than 10 tons, or equivalent heating capacity, or 4000 CFM nominal air flow, whichever is greater.

##### 4.1.4.1 Restaurants

The patron seating areas and employee workspaces within restaurants are classified as *commercial use*.

Kitchen exhaust systems designed to remove grease-laden vapor rising from cooking appliances are not covered by this standard and should be cleaned in accordance with NFPA Standard 96 and IKECA Guidelines and Best Practices.

#### 4.1.5 Healthcare

Buildings classified as *healthcare use* include any facility that either serves as a hospital, out-patient care, doctor's office, nursing home, extended care, or any other facility with a population of individuals with compromised immune systems.

#### 4.1.6 Marine

The *marine use* classification includes ships or floating vessels with passenger or crew cabins, manufacturing, processing, material handling, and storage.

#### 4.1.7 Special Use Areas

*Special use areas* include facilities with clean rooms, laboratories, or other areas with specific requirements for environmental control.

#### 4.1.8 Multi-use Buildings

In some cases, multiple building use classification types may exist within a single facility. For example, an industrial facility may have general office space, a clean room, and a manufacturing area. Projects within multi-use buildings must use appropriate environmental engineering controls as specified within this standard for each building classification type.

In the event two or more building classifications are encountered on one project, then the more stringent of the applicable environmental engineering controls must apply when isolation cannot be maintained between areas with different building use classifications.

### 4.2 HVAC Contamination Type

Cleaning methods, project specifications, environmental engineering controls, and cleanliness verification methods may vary depending on the type of contaminants found within a building and its HVAC system. Recognizing the type of contaminants present and the type of HVAC system(s) within the building are important parts of the overall project evaluation.

The HVAC systems, including air-handling units and representative areas of the HVAC system components and ductwork, must be evaluated for contamination type and levels.

An HVAC system component is considered contaminated when evidence of significant particulate debris and/or visual microbial growth exists. A system is considered to have microbial contamination when the HVAC cleanliness evaluation identifies microbial growth through visual inspection and/or analytical verification.

An HVAC system that is part of a building that has been classified as having Condition 3 mold contamination does not require further evaluation of the contaminants by an IEP for restoration to commence.

It is highly recommended that any individual taking and interpreting samples from the interior of HVAC systems be an IEP with specific training in taking samples from within such systems.

#### 4.2.1 Air-handling Units

The air-handling unit contamination evaluation should consider representative sections of components within the unit, including but not limited to filters and air bypass, heat and cooling coils, condensate pans, condensate drain lines, humidification systems, acoustic insulation, fans and fan compartments, door gaskets, and general unit integrity.

#### 4.2.2 Supply and Return Ductwork

The supply duct contamination evaluation should consider a representative portion of supply system components including, but not limited to, supply ducts, mixing/control boxes, flexible type ductwork, thermal-acoustical lining condition, reheat coils and other duct components.

The return duct contamination evaluation should consider a representative portion of all return system components including, but not limited to, return ducts, dampers, return plenums, thermal-acoustic lining condition, make-up air plenums and grilles.

### 4.3 Indoor Environmental Impact Survey

The activities associated with HVAC system inspection, system cleaning, and potential restoration of HVAC components, have the ability to adversely influence a building's indoor environment. Of primary concern is the disturbance of settled particulate and the potential for disturbed particles to be released into occupied areas.

It is highly recommended that engineering controls be used to manage the general workspace environment during cleaning and restoration work. Such controls will serve specifically to keep HVAC contaminants from entering indoor spaces. An indoor environmental impact survey is highly recommended to help determine appropriate environmental engineering controls for a project.

## 5 Environmental Engineering Controls

To the extent feasible, engineering controls must be used to assure worker safety and health, and to prevent cross-contamination. These engineering controls may include, but are not limited to source control, isolation barriers, pressure differentials, dust suppression methods, HEPA vacuuming and filtration, detailed cleaning, temperature and humidity control, and a sanitary approach.

During HVAC system cleaning procedures, appropriate environmental engineering controls must be established to control contaminants associated with the project from migrating to other spaces in the building. When disrupting biological contaminants within a mechanical system, the use of an IEP may be necessary to design the appropriate engineering and environmental controls to protect the indoor environment.

The effectiveness of environmental engineering controls may be demonstrated through the use of monitoring devices such as laser particle counters, digital pressure differential manometers, and other analytical or measuring devices. Monitoring is highly recommended in buildings containing sensitive environments or contents, when occupants have special health considerations, or when biological contaminants are being disturbed within a mechanical system.

### 5.1 HVAC Duct Pressurization

HVAC ducts must be kept at an appropriate pressure differential relative to surrounding indoor occupant spaces during all cleaning procedures and as may be required during assessment activities. It is highly recommended pressure differential be achieved through the use of a negative air machine or HEPA filtered vacuum collection equipment. Pressurization differential requirements apply to projects taking place within all building use classifications. It must be possible to demonstrate and document pressurization differential procedures.

Should field conditions allow for possible cross contamination via make-up air to a negatively pressured interior HVAC zone or duct, suitable provisions must be utilized to prevent such cross contamination.

#### 5.1.1 Vacuum Collection Equipment and Negative Air Machines

Vacuum collection equipment and/or a negative air machine must be used to establish pressure differentials in the portion of the HVAC system being serviced relative to the surrounding area. It is highly recommended the device be operated in close proximity to the connection point of the HVAC component being serviced. HVAC openings must be temporarily sealed and opened as required to maintain an appropriate pressure differential throughout the mechanical system. Installation of subsequent service openings in the portion of the HVAC system being cleaned must be performed while the system is under the appropriate pressure differential.

Negative air machines must not be used to collect large quantities of debris unless designed for that purpose.

#### 5.1.2 Pressure Differential Requirements

A continuous pressure differential must be maintained between the portion of the HVAC ductwork system being cleaned and surrounding indoor occupant spaces. The pressure differential in those portions of the HVAC system undergoing cleaning should be verified at representative locations during the cleaning process.

## 5.2 Work Site Containment

Physical activities within an indoor environment are likely to cause a temporary rise in airborne particles. Work site containment must be used to create a barrier between the work site and the rest of the building, reducing the opportunity for particles to cross contaminate other areas. In some cases the mechanical system will be completely isolated from the work site before work begins. The necessity for mechanical system isolation will be identified during the environmental engineering controls inspection. When mechanical systems are isolated from the rest of the environment it is highly recommended that the need for supplemental heating or cooling be evaluated for the project.

The extent of work site containment controls employed on a particular cleaning project is dependent upon the building use classification, HVAC system contamination evaluation, and indoor environmental impact survey. The guideline section of this standard describes several different types of containment systems and the conditions under which they may be applicable. It is highly recommended that work site containment controls be determined in cooperation with an IEP when Condition 2 or 3 mold remediation is taking place within other areas of the building.

## 5.3 Decontaminating Remediation Equipment

Tools, equipment, and instrumentation brought onto the work site must be clean and must not introduce contaminants into the indoor environment or HVAC system. All equipment must be in safe working order upon arrival at a job site. All equipment must be serviced as needed throughout a project to limit possible cross contamination from poor hygiene, and/or unsafe operating conditions for service personnel and building occupants. These requirements apply to all cleaning projects.

Tools and equipment must be cleaned and decontaminated before being transported into an uncontaminated area.

At the end of a project, tools and equipment must be cleaned and decontaminated before being removed to another area.

Tools and equipment must be cleaned and dried carefully before being returned to storage.

### 5.3.1 Equipment Hygiene Inspection

In cases of severe microbial growth (Condition 3), or where hazardous substances are known to be present within the HVAC system, or on projects taking place within healthcare facilities, there must be an on-site hygiene/integrity inspection of vacuum collection equipment prior to commencement of work. The building owner or his representative should conduct the inspection.

### 5.3.2 Operational Condition

All equipment must be maintained in good working order, consistent with applicable OSHA requirements, including, but not limited to vacuum collection equipment, power tools, pressurized air sources, electrical power cords and plugs, ground fault protection devices, vacuum collection hoses, fluid and pneumatic lines, manual and mechanical rotary brush systems, pneumatic cleaning systems, ductwork zoning devices, ladders, staging equipment, and hand tools.

### 5.3.3 Vacuum Equipment Filtration

When using vacuum collection equipment exhausting within the building envelope, it is required the equipment utilize HEPA filtration with 99.97% collection efficiency at 0.3 micron particle size. This requirement applies to all cleaning projects.

#### 5.3.3.1 Work Site Filtration Efficiency Certification

In cases of severe microbial growth (Condition 3), or where hazardous substances are known to be present within the HVAC system, or on projects taking place within healthcare facilities, filter certification by DOP testing of HEPA-filtered collection equipment at the work site is highly recommended prior to commencement of work.

## 5.4 Smoke and/or Fire Detection Equipment

Cleaning activities must not impair, alter or damage any smoke and fire detection equipment located within the facility, or attached to and serving the HVAC system. When required, temporary modifications, alterations, deactivation and reactivation of smoke and fire detection equipment, special permits, code-required notification, or other communications are the responsibility of the facility owner or the owner’s designated representative.

### 5.4.1 Temporary Controls

Conditions may require temporarily disabling detection equipment to avoid damage and/or false alarms. When temporary controls are used, confirmation that all such devices were properly functioning must be documented, and if needed, confirmed through testing.

5.4.1.1 Authority Notification

When detection equipment is deactivated, disabled or reactivated, it is the responsibility of the facility owner or his representative to inform the authority having jurisdiction about detection equipment status.

5.4.1.2 Safety Plan

When detection equipment is off-line, disabled, and subsequently reactivated, it is the responsibility of the facility owner or his representative to develop a plan for assuring safe operation of the building during such periods. The safety plan must conform to life safety regulations. The plan must define the responsibilities of each organization's designated representative involved with executing the plan for the duration of the HVAC system cleaning project.

5.5 Pressure Differentials

Pressure differentials are used to manage airflow. The use of pressure differentials is a matter of professional judgment. If pressure differentials are used, it is highly recommended contaminated areas be negatively pressurized relative to unaffected or clean areas of the building to prevent cross contamination.

The impact of HVAC cleaning activities on building pressurization and depressurization must be considered for all buildings. Potential hazards and adverse conditions resulting from dynamic building pressurization or depressurization might include back-drafting, extinguishing and/or flame roll-out of combustion appliances, altered fume-hood exhausts, adjacent thermal and relative humidity conditions, introduction of outdoor pollutants, and other problems.

Appropriate environmental engineering controls must be employed to safeguard the building environment and to control equipment that could be adversely affected by dynamic building pressurization or depressurization during HVAC system cleaning processes.

5.6 Control of Product Emission

Products used in HVAC cleaning and restoration projects may lead to the offgassing of objectionable emissions even when properly used. All products used must comply with any local, regional, or national standards and/or laws regulating the use of such agents. Cleaning agents, antimicrobials, or other chemicals must be applied in accordance with the manufacturer's written recommendations for proper handling, usage, and disposal. Antimicrobials must be properly registered for use in HVAC systems by the EPA, or the applicable governing agencies and used in accordance with their registration listing specifically for HVAC applications.

Any application of cleaning agents, antimicrobials, or other chemical agents must be performed in such a manner as to prevent employee and occupant exposure and cross-contamination.

5.7 Removal and Disposal of Contaminated Materials

All contaminated materials removed from the HVAC system must be properly contained to prevent cross-contamination. Removed debris should be double-bagged and sealed in 6-mil polyethylene bags. Materials deemed to be hazardous by governmental agencies must be handled in strict accordance with any applicable local, regional, or national codes.

All vacuum collection devices used in the contaminant removal process must be sealed prior to relocation or removal from the building. Any activity requiring the opening of contaminated vacuum collection equipment on site, such as servicing or filter maintenance, must be performed in a negatively pressurized containment area or outside the building.

It is recommended that bagged materials be placed inside a secure dumpster or transport vehicle immediately after removing them from the building. They must be handled carefully while moving them to the disposal container or site. Respirators are not required outside while transporting double-bagged materials. It is highly recommended that bags not be dropped, thrown or handled roughly. If wrapped disposal materials rupture outside the containment, transporting workers must don appropriate PPE immediately, secure the area from public access, initiate clean up (HEPA vacuuming), and contain the debris. It is recommended that dumpsters with debris be protected from scavengers and kept secured.

Non-regulated mold-contaminated ductwork components and other materials (i.e., those that do not contain asbestos, lead or other restricted waste) usually can be disposed in normal landfills as compost or construction waste. Generally, no special disposal provisions are recommended for mold-contaminated materials; however, local disposal ordinances may apply. Placing "mold" labels on bags and wrapped materials is recommended to discourage individuals from opening or removing them from the disposal site. It is recommended that label language be factual, not reactionary *(See IICRC S520).*

## 5.8 Project Planning

Project planning is required for all HVAC system cleaning projects. The project plan must address the following areas:

- Strategic monitoring plan
- Scope of work
- Trades involved and their work tasks
- Acceptable work hours
- Number of individuals to be working on the project
- Project schedule
- Certifications for equipment
- Methods to be used for the project
- Cleaning and other chemicals to be used
- Safety plans
- MSDS documents
- Materials and other documentation needed to allow for the monitoring firm or individual to complete their task.

### 5.8.1 Sequence of HVAC System Cleaning in Condition 2 and Condition 3 Environments

In buildings or areas of a structure determined to have Condition 2 or 3 microbial contamination, it is recommended to delay remediation of the HVAC system until other building mold remediation is complete, in order to avoid recontamination of the system. If this is not possible, then it is highly recommended that portions of the system exposed to or impacted by general remediation activities either be blocked off or isolated as soon as they are cleaned, re-inspected and then cleaned again if needed after demolition and reconstruction activities are complete. It may be necessary to provide for temporary heating, cooling and other environmental control for areas that are undergoing remediation if they are isolated from the building HVAC system. Often, the quality of make-up air drawn through the containment will provide satisfactory conditions. In other cases, supplemental heating, cooling or dehumidification systems can be used to provide environmental control in the spaces undergoing remediation. It is highly recommended that where supplemental systems are used inside of critical containments, they be decontaminated, bagged or wrapped prior to being removed from the workspace.

## 5.9 Ambient Air Cleaning

Ambient air cleaning is a supplemental engineering control to provide ambient airborne particle reduction during and immediately after HVAC cleaning work.

Ambient air cleaning is recommended for projects taking place within residential, light commercial, industrial and marine buildings. Ambient air cleaning is highly recommended for all commercial, healthcare and special use buildings.

### 5.9.1 Filtration Efficiency and Air Exchanges

Negative air machines or ambient air cleaners used for indoor airborne particle reduction must utilize HEPA filtration with 99.97% collection efficiency at 0.3 micrometers or greater.

Air cleaning should provide a minimum of four (4) air changes per hour in the work area or must lower indoor particle level in the work area to the documented background level.

## 5.10 Controlling Vapors or Emissions from Cleaning and Coating

A review of the types of chemicals to be used and the vapors they emit must be made before the project starts. Adequate provisions must be made to control occupant and worker exposure. Controls to exhaust chemical emissions from cleaning activities should be analyzed for their impact on building pressurization (See Section 5.5).

## 5.11 Notification and Documentation

It is highly recommended the building owner or owner's authorized representative be notified prior to the contractor bringing new products or materials into the building. These products include but are not limited to: antimicrobials, cleaning agents, coil cleaning chemicals, mastics, spray glue, coatings, sealants, and any new HVAC system components. The contractor must have applicable MSDS readily available for all chemicals that will be used during the course of the project.

# 6 HVAC System Cleaning

This section defines the minimum requirements necessary to render the HVAC system and its components clean through the removal of surface contaminants and deposits.

The HVAC system includes all interior surfaces of the facility's air distribution system that service conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning and ventilation system from the points where air enters the system, to the final point of discharge prior to entering the conditioned environment. The return air grilles, return air ducts to the AHU, the interior surfaces of the AHU, mixing boxes, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housings, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, reheat coils, flexible ductwork and supply diffusers are all considered part of the HVAC system. The HVAC system may also include other components such as dedicated exhaust and ventilation components and make-up air systems.

6.1 Mechanical Cleaning Methodology

The HVAC system must be cleaned using mechanical cleaning methods designed to dislodge and extract contaminants from within the HVAC system components. Mechanical cleaning techniques employ sizeable vacuum collection units, portable vacuum collection units, mechanical agitation systems, hand brushing tools, pressurized air sources, pressurized water sources, plus other tools and equipment to dislodge attached particulate and debris and convey it to a collection device in a safe and controlled manner.

6.1.1 Collection Devices

It is highly recommended that mechanical cleaning techniques of duct systems incorporate the use of collection devices of sufficient capacity to create a consistent pressure differential between the ductwork being cleaned and the surrounding area. These machines must be operated continuously during cleaning. Collection devices must be used to convey and collect debris and prevent cross migration of dislodged particulate during the mechanical cleaning process.

A vacuum collection device must be connected to the HVAC component being cleaned through pre-engineered openings. The vacuum collection device must be of sufficient capacity that containment of debris and the protection of the indoor environment are maintained.

6.1.1.1 Capture Velocity

When the collection device is used to convey and capture contaminants, it must maintain a sufficient velocity and pressure differential in the portion of the mechanical system being cleaned, as defined in *ACGIH Industrial Ventilation: A Manual of Recommended Practice,* to keep loosened particulate entrained and prevent settling while it is conveyed to the vacuum collection device. Table 2 defines velocities necessary for various types of materials.

**Table 2**
**Velocity Requirements for Contaminant Removal**

| **Nature of Contaminant** | **Examples** | **Design Velocity in fpm** |
|---|---|---|
| Very fine light dust | Cotton lint, wood flour, litho powder | 2500-3000 |
| Dry dusts & powders | Fine rubber dust, Bakelite molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings | 3000-4000 |
| Average industrial dust | Grinding dust, buffing lint (dry), wool jute dust, shoe dust, granite dust, silica flour, general material handling, brick cutting, clay dust, foundry (general), limestone dust, packaging and weighing asbestos dust in textile industries | 3500-4000 |
| Heavy dusts | Sawdust (heavy & wet), metal turnings, foundry tumbling barrels and shake out, sand blast dust, wood blocks, hog waste, brass turnings, cast iron boring dust, lead dust | 4000-4500 |
| Reprinted from ACGIH's *Industrial Ventilation: A Manual of Recommended Practice, 23rd Ed.* | | |

6.1.2 Mechanical Agitation

Dislodging contaminants from duct system components must be accomplished through mechanical agitation techniques. Mechanical agitation techniques requires the use of mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces, such that debris may be safely conveyed to vacuum collection devices. Agitation devices may include cable driven brush systems, compressed air systems, power water wash systems, pneumatic and electric driven brushes, and hand tools such as contact vacuum brushes.

6.1.3 Contact Vacuuming

Contact vacuuming utilizing HEPA-filtered equipment must be performed in designated areas of the HVAC system. Cleaning must be performed by the application of the vacuum in combination with a brush attachment directly to the contaminated surface.

It is highly recommended the HVAC component being remediated using HEPA contact vacuuming also be negatively pressurized using a vacuum collection device.

#### 6.1.4 Power Washing, Steam Cleaning and Wet Cleaning

Power washing, steam cleaning, or any other form of wet process cleaning of HVAC system components must not damage the components. It is highly recommended that cleaning agents or water not be applied to porous HVAC system components.

All HVAC components requiring wet process cleaning must be cleaned in accordance with the chemical manufacturer's written instructions and applicable federal, state, and local regulations. On occasion, treatments designed to inhibit growth or re-soiling may be applied following cleaning. These should be applied according to manufacturer's directions. Normally, these will not be rinsed off following application.

### 6.2 Component Cleaning

Cleaning methods must be employed such that all HVAC system components must be visibly clean and capable of passing cleanliness verification tests (See Section 13).

Dampers and any air-directional mechanical devices inside the HVAC system must have their position marked prior to cleaning and, upon completion, must be restored to their marked position.

Registers, grilles, diffusers, and other air distribution devices must be cleaned and restored to their previous position.

#### 6.2.1 Air Handling Units, Terminal Units (control boxes, dual duct boxes, etc.), Blowers, and Exhaust Fans

It is highly recommended that air-handling unit (AHU) internal surfaces, condensate collectors and drains be cleaned by mechanical scrubbing methods. An appropriate drainage system with sufficient capacity must be in place and pre-tested prior to beginning wet cleaning procedures. All air-handling components such as coils, blower wheels, blower housings and related components must be cleaned. During wet cleaning, it is highly recommended that precautions be taken to assure that fiber glass insulation and other porous materials do not get wet.

Evaporator coils, blowers, blower housings, and drain pans will likely require multiple cleanings when attempting to remediate mold contamination. Areas expected to be cleaned should include blowers, fan housings, plenums (except ceiling supply and open return plenums), scrolls, blades, vanes, shafts, baffles, dampers and drive assemblies. It is highly recommended all visible surface contamination deposits be removed in accordance with this standard.

#### 6.2.2 Duct Systems

Duct systems must be cleaned to remove all visible contaminants and be capable of passing cleanliness verification tests (See section 13). Inaccessible areas must be accessed by service openings constructed in the system that are large enough to accommodate mechanical cleaning procedures (See Section 6.4).

### 6.3 Service Openings

Service openings must be made as required to satisfactorily perform assessment, cleaning and restoration procedures.

All service openings must comply with ACR 2006 Section 14, *Requirements for the Installation of Service Openings in HVAC Systems*, applicable UL and NFPA standards, as well as national, state, and local requirements.

## 7 Coil Surface Cleaning

It is Highly Recommended that all portions of each coil assembly be cleaned. Both upstream and downstream sides of each coil section must be accessed for cleaning. Where limited access is provided between close proximity or zero-tolerance heating coils in an AHU, cleaning may require removal and/or replacement.

### 7.1 Coil Inspection and Cleaning Process

For the purposes of this standard a coil is defined as an evaporator, chilled water, hydronic, steam, hot gas or heat pipe which is located within the air stream of an HVAC system for the purposes of indoor environmental control.

The process begins with an inspection. The substances deposited on the coil help determine the initial selection of the cleaning protocol. There are two (2) categories of coil cleaning. Coil reconditioning will utilize Type-1 or Type-2 cleaning methods. Both Types require usage of HEPA filtered negative air machines when exhausting within an occupied space. HEPA filters are recommended, but not required, when machines are exhausted outside of building.

Negative air machines must be operated continuously during the complete coil reconditioning process. The coil must be physically isolated from the duct system during the cleaning process to ensure disrupted particulate does not migrate to or redeposit on unintended areas.

## 7.2 Coil Inspections

7.2.1 Preliminary Coil Inspection– A visual inspection of the coil and drain pan shall be conducted prior to cleaning a coil. The data gathered from the preliminary inspection will determine whether or not Type 1 or Type 2 cleaning is required. If it is determined the coil cannot be properly cleaned through Type 1 methods, Type 2 methods are required. When the preliminary visual inspection reveals suspect microbial matter on any portion of the coil or drain pan, Type 2 cleaning methods are required. When the metal fins of the evaporator coil are deteriorating or showing signs of corrosion or excessive metal loss, replacement is recommended. When the inspection reveals that any surfaces of the coil or drain pan cannot be accessed for cleaning, it is highly recommended that the coil be removed for cleaning.

### 7.2.2 Type 1 Post Cleaning Inspection

This inspection is required after any Type 1 coil cleaning has been completed. If debris still remains on the coil after Type 1 cleaning, Type 2 cleaning is required.

### 7.2.3 Type 2 Post Cleaning Inspection

Type 2 inspections are conducted after completion of any Type 2 cleaning methods. If debris still remains on the coil after Type 2 cleaning, the process should be repeated. When debris cannot be removed using Type 2 cleaning methods, replacement may be necessary.

### 7.2.4 Measuring the Effectiveness of Cleaning Efforts

Visual observations of coil surfaces can be misleading. Therefore a static pressure drop should be obtained before and after the cleaning process to demonstrate the effectiveness of such efforts. This type of measurement, which can be performed using a magnehelic gauge, or manometer, is a more accurate indicator for the presence of debris that has either been removed or remains within the coil.

Ideally, the reconditioning efforts should result in a static pressure drop sufficient to allow the HVAC system to operate within 10% of its nominal, and/or design (if known) volumetric flow, which if needed can be verified by an appropriate air test and balance procedure. However it should be understood that other factors such as air leakage, fan blade condition, compromised duct, permanently impacted coils (which are not capable of being fully cleaned) and other factors, can have an effect on the overall static capability and subsequent performance of the HVAC system.

## 7.3 Type 1 and Type 2 Coil Cleaning Methods

### 7.3.1 Type 1 Coil Cleaning

Type 1 methods of coil cleaning are appropriate for removing loose dust, dirt or debris collected upon evaporator coil surfaces. Physical removal of debris is accomplished through a variety of methods which may include:

- HEPA filtered contact vacuuming the coil surfaces with a vacuum capable of generating a minimum of -40 inches water lift. HEPA filtered contact vacuuming must be used in conjunction with the evaporator coil being maintained with a negative pressure differential to the general work environment.
- Contact vacuuming may require the use of crevice tools and brushes.
- Brushes may be used for penetrating between coil fins and up to the first row of refrigerant tubes without damaging the fins.
- Compressed air accelerator guns and wands may be used to dislodge debris embedded between the evaporator coil fins without damaging the fins.
- Evaporator fin combs and fin straightening tools designed to restore the evaporator coil fins after initial cleaning

### 7.3.2 Type 2 Coil Cleaning

Type 2 cleaning methods are appropriate for removing adhered debris on all coil, drain pan and drain line surfaces. Type 2 cleaning should be performed after non-adhered particulate has been removed using Type 1 methods. Type 2 cleaning may include the following methods:

- All methods under Type 1
- It is not always possible to remove all motors and electrical equipment from the coil area. However, it is always possible to either remove, isolate and/or protect electrical equipment.
- Application of coil cleaning products. (Must be used in accordance with the manufacturer's product labeling.)
- Usage of electric chemical coil cleaner application equipment.
- Usage of water washing at normal water line pressure.

- Usage of mechanically pressurized water washing equipment.
- Usage of hot water or steam cleaning equipment.
- Employing HEPA filtered wet contact vacuums or standard wet contact vacuum equipment located outdoors.
- Temporary Drainage systems for chemical cleaning processes with sufficient capacity to capture and discharge wastewater from the cleaning process.
- Creating temporary barriers to ensure that fiberglass insulation and other porous materials will not get wet or come in contact with chemical applications. At no time should any porous materials surrounding the coil section being cleaned become saturated with liquids, chemicals or water.
- * Coils that cannot be effectively cleaned in place should be removed from the mechanical system for cleaning.
- The condensate drain pan and drain line must be cleaned, reconditioned and completely flushed. The condensate drain pan must be inspected to verify proper drainage operation before and after cleaning.
- **Note**: Cleaning methods and products must be pre-tested and determined not to cause damage to, or erosion of, the coil surface or fins, and must conform to coil manufacturer recommendations when available. In order to limit damage to coils it is recommended that only coil cleaning solutions that are as close to ph neutral as possible are used. It is highly recommended that coils be thoroughly rinsed with fresh water in order to remove coil cleaner residue from the coil surfaces.

  *As of July 1, 1992, Section 608 of the US EPA's Clean Air Act prohibits individuals from knowingly venting ozone-depleting compounds (generally CFCs and HCFCs) used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (appliances).

### 7.4 Electric Resistance Coils

When cleaning electric resistance coils, the power source to the coils must be deenergized and locked out/tagged out in accordance with OSHA Standards.

## 8 Remediation of Mold and Other Biological Contamination

This section defines processes for remediating mold and other biological contamination within an HVAC system. It is highly recommended the remediation plan for mold decontamination include removal of contaminated materials or employ aggressive cleaning techniques when removal is impractical. Removal of contaminated porous HVAC system materials is recommended (See ACGIH *Bioaerosols: Assessment and Control,* 1999*).*

### 8.1 Cleaning Methods

Surface cleaning must be performed using mechanical agitation methods to remove particulate, debris, nutrient sources and surface contamination. Mechanically cleaned surfaces must be capable of passing cleanliness verification methods as defined in this standard (See Section 13).

### 8.2 Removal of Mold Contaminated Porous Materials

It is highly recommended that porous materials with actual fungal growth (Condition 3) be removed. The exposed non-porous substrate underneath the porous materials must be mechanically cleaned and treated before new replacement material is installed.

When removal of all Condition 3 contaminated porous material cannot be performed, partial removal to the greatest extent possible should take place. This must be followed by surface cleaning of remaining material using mechanical cleaning methods.

### 8.3 Surface Treatments

It is highly recommended mechanical cleaning procedures be performed on porous HVAC materials prior to the application of any surface treatments such as mechanical repair coatings. Surface treatments may be used to restore the integrity of material surfaces only as an interim control measure, and must not be used as a substitute for mechanical cleaning or complete removal. Surface treatments must only be applied after confirming the system has been cleaned, utilizing the cleanliness verification tests as defined in this standard (See Section 13).

#### 8.3.1 Antimicrobial Surface Treatments and Coatings

Use of antimicrobial treatments and/or coating products may be considered only after mechanical surface cleaning has been performed and the need for such treatment has been deemed necessary.

When used, antimicrobial treatments or coatings must be applied in strict accordance with the manufacturer's written recommendations or EPA registration listing.

Any antimicrobial product used in an HVAC system must be specifically registered by the EPA or other applicable regulatory agency for use in HVAC systems, have undergone a comprehensive risk assessment for such use, and contain specific and detailed label directions. If the label directions cannot be followed completely, use must be avoided.

## 9 Fiber Glass Duct System Components

It is highly recommended that fiber glass duct liner or duct board present in equipment or ductwork be cleaned with HEPA contact vacuuming equipment, or other appropriate equipment. The components being cleaned must be under a consistent negative pressure differential to the surrounding work area. Fiber glass materials that become wet with cleaning fluids or water during cleaning should be reassessed and potentially discarded after the incident has occurred.

It is highly recommended that the mechanical cleaning methods selected for duct liner or fiber glass duct board not create abrasions, breaks or tears to fiber glass liner or duct board surfaces. Cleaning methods used must be capable of rendering the system visibly clean in accordance with this standard and capable of passing applicable cleanliness verification requirements (See Section 13).

Thermal acoustic internal fiber glass liner, and other thermal acoustic liner areas with visual signs of degradation, such as delaminating, abrasions, breaks, or tears may be treated with the appropriate repair products only after mechanical cleaning has been performed. If repairs are not practical or desired, it is highly recommended that damaged materials be removed and replaced.

### 9.1 Resurfacing Fiber Glass Surfaces

Resurfacing of thermal acoustic fiber glass components such as duct liner or duct board within the HVAC system should be considered if the materials show visual signs of abrasion or degradation or if the project requires a change of the fiber glass' original surface to a smoother surface for reduction of the fiber glass' ability to capture and collect particulate. An assessment must be made to determine whether the surface of the component will provide a strong, bondable surface for the coating material after undergoing proper mechanical cleaning.

Fiber glass materials determined to be too unstable to support a resurfacing product in accordance with manufacturer's written instructions or which are not capable of providing a long-term, bondable surface are beyond restoration. In such cases removal and replacement of the damaged porous material is highly recommended.

Fiber glass duct system materials with stable and consistent surface integrity may not need resurfacing. The benefits of resurfacing should be evaluated on a case-by-case basis.

#### 9.1.1 Coatings and Insulation Repair Products

All resurfacing agents for use on surfaces within the HVAC system must be classified as having a flame-spread rating acceptable under industry standards including UL Standard 723 or ASTM E-84, or applicable local codes.

Resurfacing products must be applied in strict accordance with the manufacturer's written instructions. Prior to coating application, all surfaces upon which a re-surfacing coating or agent are to be applied must be properly cleaned and capable of passing the cleanliness verification requirements of this standard (See Section 13).

Treatment of rusted surfaces must only be performed after mechanical cleaning and proper preparation of the surfaces to be treated.

In no case must a coating or adhesive be applied prior to, or in lieu of, mechanical cleaning methods, or prior to cleanliness verification.

### 9.2 Damaged Fiber Glass Material

When there is evidence of damage, deterioration, delaminating, friable material, mold growth, biological reservoirs or excessive moisture accumulation such that cleaning or resurfacing cannot restore fiber glass materials, it is highly recommended that these materials be replaced.

In the event fiber glass materials must be replaced, all replacement materials must conform to applicable industry codes and standards, including those of UL, ASTM and SMACNA.

#### 9.2.1 Thermal-Acoustic HVAC Insulation Replacement

All metal surfaces of the duct system that have undergone removal of degraded fiber glass duct liner or duct board insulation or thermal acoustic material, must have the base surface scraped clean and must be free of loose, visible debris prior to installation of new insulation. In the event the fiber glass removal was due to mold contamination the base surface should be cleaned to a Condition 1 status prior to reapplying any fiber glass insulating products.

Installation of thermal-acoustic HVAC insulation common to the air stream must comply with the following requirements as well as applicable SMACNA and NAIMA Standards.

All materials used for insulation replacement within the HVAC system must meet or exceed the specifications of the original materials or current applicable codes. Installation of the replacement materials must comply in strict accordance with the manufacturer's written recommendations.

All transverse joints of the replacement insulation must be properly sealed with an appropriate mastic product or fitted with metal nosing at each longitudinal joint in accordance with applicable industry standards.

Following completion of the installation of replacement materials, all new fiber glass surfaces must be capable of meeting NADCA cleanliness verification requirements. Fiber glass thermal-acoustic insulation materials may require mechanical cleaning following installation to meet NADCA cleanliness verification requirements (See Section 13).

## 10 Restoration and Repair of Mechanical Systems

Restoration of HVAC system components is the process of preparation, refurbishment, resurfacing, repair, or replacement of any surface common to the air stream. Restoration procedures must only be performed after mechanical cleaning.

Air side surfaces of HVAC systems found to be compromised during the HVAC cleanliness evaluation or during cleaning must be documented for restoration or replacement to industry standards, as required.

HVAC system components subjected to catastrophic events such as fire, smoke, flood, or water-damage must be subject to restoration procedures. Component degradation that results in compromised system performance must be corrected through restoration procedures if possible. HVAC component replacement must take place if cleanliness levels specified in this standard cannot be achieved through mechanical cleaning and restoration methods.

### 10.1 Non-Porous Material Restoration

When the surface conditions of non-porous components following cleaning reveal a surface that will contribute particulate and/or odors to the air stream and/or adversely affect the quality of the air moving through the system, restoration should be performed.

### 10.2 Porous Material Restoration

Cleaning, restoration, and removal of porous insulation are described in Section 8 of this standard.

### 10.3 External HVAC System Insulation

In those areas where accessing the system and/or ductwork requires the removal of external insulation and/or vapor barriers, these areas must be restored to their original functional, thermal, and vapor retardant integrity upon completion of the work and prior to system reactivation.

### 10.4 Flooding/Water-Damage

All HVAC system surfaces and components subjected to water-damage due to flooding must be evaluated and categorized according to industry-recognized methods to determine salvageability and restoration. Of particular importance is determining the category of water causing the damage, as defined in IICRC Standard S500 for professional water damage restoration. To a large extent, the category of water entering the HVAC system will dictate methods of cleaning and environmental engineering controls.

Any system components and/or ducts deemed salvageable must be thoroughly cleaned.

### 10.5 Fire/Smoke Damage

All HVAC system components subjected to heat and smoke must be evaluated for restoration. Any components and/or surfaces unable to withstand proper mechanical cleaning and restoration are deemed beyond salvage and must be replaced.

All porous surfaces subjected to fire/smoke damage must be evaluated following proper mechanical cleaning for friability and odor retention. Any areas assessed as friable must be replaced or resurfaced.

Following cleaning, any component surface exhibiting damage due to heat exposure must be restored to an acceptable condition or replaced.

### 10.6 HVAC System Repair

HVAC components requiring repair due to pre-existing damage or degradation that are discovered during the cleaning process must be documented and brought to the attention of the building owner or representative.

No cleaning process must be performed that will damage a properly designed, installed, and structurally sound HVAC system and its components, or negatively affect the performance, operation, or normal life expectancy of the system.

Repair or replacement of malfunctioning mechanical devices is not included in the scope of this standard. Restoration does not include the sealing of air leaks within duct systems.

## 11 Project Monitoring

It is recommended that every HVAC system cleaning project specification include a monitoring plan. The plan must conform to the environmental engineering controls defined in Section 5 of the ACR Standard.

The process of developing a monitoring plan should involve the building owner or representative. The planning process must consider the following issues:

- Protection for building occupants and contractor's employees during HVAC system cleaning.
- Protection of sensitive equipment, building contents and the need for containment zones in addition to those required in Section 5 of this standard.
- Protection and deactivation of building safety controls such as fire and/or smoke detectors and the implications for occupant safety and false alarms.

### 11.1 Project Monitoring Plan Elements

When applicable, the following project monitoring items should be incorporated in the implementation of a typical monitoring plan.

- Document project startup orientation meeting for contractor and subcontractor job superintendents.
- Document the type of equipment to be introduced to the work site.
- Verify acceptable hygiene condition of the equipment prior to introducing the equipment into the work site.
- Monitor indoor environmental conditions so that the occupants will not be adversely affected by the cleaning work. This may be performed by an IEP.
- Monitor containment zone isolation effectiveness.
- Monitor that only the chemicals and materials which have been approved for use on the specific project are brought on site.
- Monitor the use of personal safety equipment.
- Monitor the effectiveness of the cleaning methods in accordance with the project specifications and the ACR standard.
- Document areas that have been cleaned.
- Monitor proper closure methods for service openings.
- Provide project close-out documentation.

## 13 Health and Safety

The U.S. Occupational Safety and Health Act of 1970 provides requirements for workplace safety and health. The Act is administered by the Occupational Safety and Health Administration (OSHA) under the United States Department of Labor (DOL). The scope of HVAC system cleaning projects can vary so much, that it is impossible for the ACR standard to address compliance with 29 CFR 1910 and 29 CFR 1926 in a complete manner.

### 12.1 Cleaning Contractors

Cleaning contractors must comply with all applicable federal, state and local requirements for protecting the health and safety of their employees, building occupants, the general public and the environment.

The contractor must comply with all applicable OSHA regulations. If the requirements of this standard and OSHA regulations are not in agreement, then the more strict requirements must always apply. In the United States, applicable OSHA regulations include, but are not limited to, the following:

- 29 CFR 1910.146 Permit Required Confined Spaces
- 29 CFR 1910.134 Respiratory Protection
- 29 CFR 1910.1200 Hazard Communication
- 29 CFR 1910.147 Control of Hazardous Energy
- 29 CFR 1926 Subpart M - Fall Protection
- 29 CFR 1910 Subpart I - Personal Protective Equipment (1910.132 to 1910.139)

The contractor should also be aware of other standards and guidelines affecting both particulate removal and mold or biological removal procedures. Applicable standards and guidelines include:

- IICRC S500, *Standard and Reference Guide for Professional Water Damage Restoration*

- IICRC S520, *Standard and Reference Guide for Professional Mold Remediation*
- *Mold Remediation in Schools and Commercial Buildings*, EPA Publication 402-K-01-001
- *A Brief Guide to Mold, Moisture, and Your Home*, EPA Publication #402-K-02-003
- *Guidelines on Assessment and Remediation of Fungi in Indoor Environments*, New York City Department of Health & Mental Hygiene, Bureau of Environmental & Occupational Disease Epidemiology
- ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*
- Indoor Air Quality Association *Guideline 01*

## 13 Verification of HVAC System Cleanliness

It is highly recommended that the cleanliness verification be performed directly after an HVAC system component has been cleaned and prior to the component being used in operation. All verification tests must be conducted prior to the application of any surface treatments of the component's surface. This post-cleaning verification process applies to all porous and non-porous components within the HVAC system. The verification inspection is not intended to determine the reduction in biological levels. In order to measure the appropriate reduction in biological contamination it is highly recommended that the IICRC S520 mold remediation standard be used in combination with these verification procedures.

The HVAC system cleanliness verification is not designed to determine if an HVAC system needs to be cleaned. In order to determine if an HVAC system needs cleaning see Section 3 of this standard.

Methods of cleanliness verification are described below.

### 13.1 Method 1 - Visual Inspection

A visual inspection of porous and non-porous HVAC system components must be used to assess that the HVAC system is visibly clean. An interior surface is considered visibly clean when it is free from non-adhered substances and debris. If a component is visibly clean then no further cleanliness verification methods are required.

If the Method 1 - Visual Inspection is inconclusive regarding acceptable particulate reduction, then Method 2 - Surface Comparison Testing must be performed (See Section 13.2).

### 13.2 Method 2 - Surface Comparison Testing

The Surface Comparison Test can be used to determine cleanliness of both non-porous (metal) and porous (fiber glass) HVAC component surfaces. The component's surface conditions are evaluated by comparing visible characteristics of the test surface before and after implementing a specific procedure of contact vacuuming as defined in Section 13.2.2.

#### 13.2.1 Contact Vacuum Equipment Criteria

The testing contact vacuum must be HEPA filtered and capable of achieving a minimum of -40 inches of water gauge. The contact vacuum should be fitted with a 2.5" round nylon brush attached to a 1.5" diameter vacuum hose.

#### 13.2.2 Test Method

The vacuum brush should be attached to the contact vacuum and the device should be running. The brush must be passed over the surface test area four (4) times, with the brush depressed against the surface being tested using light to moderate pressure (as used in routine cleaning).

When the procedure described above has been completed, a comparison must be made to determine if the visible characteristics of the surface have changed significantly. The HVAC component surface is considered to be clean when there is no significant visible difference in the surface characteristics.

If surface comparison testing is inconclusive, then the Method 3 - NADCA Vacuum Test protocol may be used to make a final cleanliness determination. The Method 3 test procedure can be used for non-porous system components only. The NADCA Vacuum Test does not apply to porous system components.

### 13.3 Method 3 - NADCA Vacuum Test

The NADCA Vacuum Test is used for scientifically evaluating remaining particulate levels of cleaned, non-porous HVAC component surfaces. Using this procedure, a template (See Section 13.3.1.4) is applied to the suspect component's airside surface. A vacuum cassette with filter media is attached to a calibrated air pump and the open face of the filter cassette is passed over two 2 cm x 25 cm openings within the template. At no time can any portion of the vacuum cassette directly contact the component surface being tested. The template is specifically designed to allow the cassette to ride above the surface being tested. Airflow is accelerated through a narrow opening between the template and the test surface of the component, allowing any latent remaining particulate from the component's surface to be dislodged through increased velocity and impinged onto the filter media within the vacuum cassette. After this procedure is complete the cassette is prepared and weighed to determine the amount of total debris collected on the filter media.

13.3.1 Test Components

13.3.1.1 Air Pump

An air sampling pump capable of drawing 15 liters per minute through a cassette containing 37 mm matched weight filters (two 0.8 micrometer pore size mixed cellulose ester (MCE) filters in series) must be used.

13.3.1.2 Filter Media

Filter media within the vacuum cassette must be 37 mm mixed cellulose ester (MCE) matched weight filters (0.8 micrometer pore size preloaded in three-piece cassette).

13.3.1.3 Calibration Device

The air pump must be calibrated using a calibration device that is accurate to ±5% at 15 liters per minute.

13.3.1.4 Template

The template must be 15 mil thick (0.381 mm) and must provide a 100 $cm^2$ sampling area consisting of two 2 cm x 25 cm slots at least 2.5 cm apart.

The standard size openings for the NADCA Vacuum Test Template are 2 centimeters in width by 25 centimeters in length. At times, templates with slots of this size may not fit in a space where testing is necessary or desired. Slots of other sizes may be utilized, subject to the specifications herein.

The template opening size and shape can vary provided that (1) the total area to be sampled is equal to 100 square centimeters; (2) the maximum width of the opening does not exceed 3.7 centimeters, so that the sample cassette will not touch the surface being sampled; and (3) the minimum opening width is greater than or equal to 2.0 centimeters.

13.3.2 Sampling Method

Secure the template to the surface to be sampled so that it will not shift position during sample collection. The template must lay flat against the surface to be sampled. The surface to be sampled must be dry. The air-handler must not be running when the sampling is being conducted.

Remove protective plugs from the cassette. Cassettes should be wrapped with shrink tape. Attach the outlet end of the cassette to the air pump tubing.

Adjust air flow using an appropriate calibration device to 15 liters per minute. Once the flow rate is calibrated, remove the clear plastic inlet cover, making sure that the retainer ring (middle section) stays in place.

Vacuum the open area of the template by sliding the cassette from one end of each template opening to the other. The cassette must be moved at a rate not greater than 5 cm per second. The edges of the cassette must always rest on the template. The cassette must not touch the duct surface. Each template's openings must be vacuumed twice (once in each direction).

Throughout the vacuum process, hold the cassette so that it touches the template surface, with no downward pressure being applied.

After the template's openings have been vacuumed twice, put the clear plastic cover back on the cassette. The vacuum pump may now be turned off. Then replace the plugs.

Label the cassette and record the area of the surface sampled. The cassette may now be prepared and weighed to determine the amount of debris collected on the filter media. Analysis based on the National Institute for Occupational Safety and Health (NIOSH) Method 0500 (total nuisance dust) must be used.

Scale sensitivity should be equal to or greater than 0.7 milligram and must be calibrated in accordance with the manufacturer's written recommendations. Results must be reported in milligrams per 100 square centimeters (mg/100 $cm^2$) of sampling area.

Generally, samples are sent to a laboratory for testing, however, sampling equipment is capable of being brought on the work site. It is highly recommended that samples be taken by an IEP and analyzed by an accredited laboratory.

13.3.3 Acceptable Cleanliness Level

To be considered clean by the NADCA Vacuum Test, the net weight of the debris collected on the filter media must not exceed 0.75 mg/100 $cm^2$.

## 14 Requirements for the Installation of Service Openings in HVAC Systems

### 14.1 Applicable Documents

The following documents of the issue currently in effect form a part of this standard to the extent specified herein.

14.1.1. NADCA Publications

- National Air Duct Cleaners Association, Washington, DC.
- *Introduction to HVAC System Cleaning Services,* 1995.

14.1.2. UL Publications

Underwriters Laboratories, Inc.

- UL 181*, Factory-Made Air Ducts and Air Connectors,* 1995.
- UL 181A*, Closure Systems for Use with Rigid Air Ducts and Air Connectors,* 1994*.*
- UL 181B*, Closure Systems for Use with Flexible Air Ducts and Air Connectors,* 1995.
- UL 723, *Test for Surface Burning Characteristics of Building Materials,* 1996.

14.1.3. NFPA Publications

National Fire Protection Association, Batterymarch Park, Qunicy, MA

- NFPA 90A*, Installation of Air Conditioning and Ventilating Systems*, 1993.
- NFPA 90B*, Warm Air Heating and Air Conditioning Systems*, 1993.

14.1.4. SMACNA Publications

Sheet Metal and Air Conditioning Contractors National Association, Inc., Chantilly, VA

- *HVAC Duct Construction Standards-Metal & Flexible*, 1985.
- *Fibrous Glass Duct Construction Standards*, 1992.

14.1.5. NAIMA Publications

North American Insulation Manufacturers Association, Alexandria, VA

- *Fibrous Glass Ductliner Standard*, 1994.
- *Cleaning Fibrous Glass Insulated Air Duct Systems*, 1993.

### 14.2 General Requirements

*The requirements shown below apply universally to both removable duct access doors and permanent panels:*

Service openings installed into the system shall not degrade the structural, thermal, or functional integrity of the system.

Service openings shall be closed in an air- tight manner such that no apparent leakage inward or outward is detectable.

Service openings shall not hinder, restrict, or alter the airflow within the duct.

Service opening construction materials and methods must be in compliance with industry standards and local codes, using materials acceptable under those standards and codes.

Materials used in the fabrication of duct access doors and permanent panels shall be those classified for flammability and smoke spread if the material is exposed to the internal airstream. These materials are classified as having a flame-spread rating of not over 25 without evidence of continued progressive combustion and a smoke-developed rating of not over 50, as determine by *UL 723.*

Metals used in the fabrication and installation of duct access doors and permanent panels shall be resistant to atmospheric corrosion and shall not be used in combinations that will cause galvanic action which might deteriorate any part of the system formed from such material.

All materials used in the fabrication of service openings shall be suitable for continuous exposure to the temperature and humidity conditions of air within the HVAC system.

All tapes used in the installation and closure of service openings shall meet the requirements of *UL-181A* and be properly labeled as such.

Air duct coverings shall not be installed so as to conceal or prevent use of any service opening.

Where a service opening is necessary in an air duct located above the ceiling of a fire-rated floor/roof-ceiling assembly, access shall be provided in the ceiling and shall be designed and installed so as not to reduce the fire resistance rating of the ceiling.

All service openings shall comply with applicable UL and NFPA standards, as well as local and state codes.

14.3 Permanent Closure Panels

Closure panel seals shall be permanent.

Metal panels used for closing service openings in the HVAC system shall be of a like gauge or heavier.

Metal panels used for closing service openings shall be mechanically fastened (screwed,riveted, welded, or clamped) every 4" on center. The panel shall overlap the ductwork surfaces by a minimum of 1" on all sides.

Metal panels used for closing service openings shall be sealed with gaskets, caulking, mastic, or suitable tape.

14.4 Removable Duct Access Doors

Duct access door frames and jamb seals shall be permanent.

Metals used in the fabrication of removable duct access doors for installation into the air duct system shall be 24 gauge minimum. The gauge of the duct access door shall be based on the pressure class of the duct system.

14.5 Fibrous Glass System Service Openings

Service openings installed in fibrous glass portions of a system must be constructed and closed in such a manner that there are no exposed fibrous glass edges within the system common to the airstream.

Any insulation removed during the installation of a service opening must be replaced (with insulation of the same thickness) or repaired so that there are no breaks or openings that would form paths for heat loss or gain, or for water vapor condensation to occur.

14.6 Drilled 1" Service Openings

Drilled 1" service openings must be closed with materials having a flame-spread rating of not over 25 without evidence of continued progressive combustion and a smoke-developed rating of not over 50.

Any exposed fibrous glass edges within the duct should be sealed with no breaks or gaps in the insulation.

14.7 Flexible Duct Systems

Service openings shall not be made in flexible ductwork.

**Reference Documents**


Air Conditioning and Refrigeration Institute

*ARI 410-91 Forced Circulation Air Cooling and Air Heating Coils, 1991.*

Air Movement & Control Association

*AMCA-99-86, Standards Handbook, 1986.*

American Conference of Governmental Hygienists

*Bioaerosols: Assessment and Control, 1999.*

*Industrial Ventilation: A Manual of Recommended Practice, 23rd Edition, 1998.*

American Industrial Hygiene Association

*Field Guide for the Determination of Biological Contaminants in Environmental Samples, 1996.*

American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

*ASHRAE 33-78, Methods of Testing Forced Circulation Air-Cooling and Air-Heating Coils, 1978.*

*ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, 1989.*

*ASHRAE Fundamentals Handbook, Terms and Definitions, 2001.*

ASTM International

*E84-00a Standard Test Method for Surface Burning Characteristics of Building Materials.*

*C1071–00 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)*

Indoor Air Quality Association (IAQA)

*Guideline 01*

Institute of Inspection, Cleaning and Restoration Certification (IICRC)

*IICRC S500, Standard and Reference Guide for Professional Water Damage Restoration, 1999.*

*IICRC S520 Standard and Reference Guide for Professional Mold Remediation, 2003.*

International Kitchen Exhaust Cleaning Association (IKECA)

*Guidelines and Best Practices, 2004.*

National Air Duct Cleaners Association (NADCA)

*NADCA Standard 03, Requirements for Testing Vacuum Collection Equipment, 2001.*

*NADCA Standard 05, Requirements for the Installation of Service Openings in HVAC Systems, 1997.*

*Understanding Microbial Contamination in HVAC Systems, 1996.*

National Fire Protection Association

*NFPA 90 A, Installation of Air Conditioning and Ventilation Systems, 1993.*

*NFPA 90B, Warm Air Heating and Air Conditioning Systems, 1993.*

*NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, 2001.*

*NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.*

National Institute for Occupational Safety and Health

*Manual of Analytical Methods, Third Edition, February 1984.*

New York City Department of Health, Environmental Occupational Disease Epidemiology

*Guidelines on Assessment and Remediation of Fungi in Indoor Environments, 2000.*

North American Insulation Manufacturers Association

*Fibrous Glass Duct Construction Standards (Fifth Edition).*

*Cleaning Fibrous Glass Insulated Duct Systems (2002 Edition)*

Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

*HVAC Duct Construction Standards – Metal and Flexible, Second Edition, 1995.*

*Fibrous Glass Duct Construction Standards, Sixth Edition, 1992.*

Underwriter Laboratories, Inc.

*UL 181, Factory-Made Air Ducts and Air Connectors, 1995.*

*UL 181A, Closure Systems for Use with Rigid Air Ducts and Air Connectors, 1994.*

*UL 181B, Closure Systems for Use with Flexible Air Ducts and Air Connectors, 1995.*

*UL 723, Test for Surface Burning Characteristics of Building Materials, 1996.*

United States Environmental Protection Agency (EPA)

*Building Air Quality, December 1991.*

*Mold Remediation in Schools and Commercial Buildings, March 2001.*

# Guideline to Assessment, Cleaning, and Restoration of HVAC Systems *ACR 2006*

The following guideline provides supplementary reference information for users of ACR 2006. The material contained within the guideline does not carry the official status of a standard, and the guideline recommendations are not mandatory under ACR 2006. However, the two sections compliment one another and should always be considered in tandem.

## Chapter 1
## Containment Engineering Strategies

Containment engineering strategies are used to isolate a workspace from other areas of a building. Most containment engineering strategies involve creating barriers or pressure differentials that prevent the unintended migration of airborne particulate into non-intended zones. Depending on the usage classification of a building and the type of contaminants within the HVAC system, several different containment engineering strategies may be employed. Four levels of work site containment controls are described below. The requirements for each level increase in stringency. The highest levels of containment engineering are applicable to areas where significant mold or other biological growth exists, or where the building use classification mandates special protection, as in a healthcare facility.

As new information comes forth regarding mold and biological contaminants and their affect on human health, the containment engineering strategies recommended below may require enhancements. These containment engineering strategies are specifically designed with respect to protecting the indoor environment, contractors and occupants from HVAC component cleaning and duct cleaning processes.

**Level 1 Containment – Minimum Engineering Controls**

Level 1 Containment is applicable to HVAC system cleaning in buildings classified as residential, industrial, light commercial and marine, provided that there is no known mold or biological contamination. If mold or biological contamination is known to exist, Level 2 Containment may apply. The following protective actions are required under Level 1 Containment strategies.

- Protective Coverings – Clean, protective coverings must be used within each work area. Protective coverings must extend beyond the work area to provide protection of flooring, equipment, and furniture whenever necessary.
- Cleaning Equipment – Inlet openings on all vacuum collection devices and negative air machines must be properly sealed during transport and when the equipment is not in use. Vacuum hose openings must be sealed during transport. All tools, equipment, and equipment components that enter the HVAC system from an occupied space must be wet-wiped, HEPA vacuumed, or sealed in a disposable polyethylene bag during removal from the HVAC system.
- Cross Contamination Control – Suitable provisions must be made to control contaminant discharge from the HVAC system and cross contamination into occupied space during the cleaning process. This may require temporary sealing of existing duct joints, seams and other system components.

**Level 2 Containment – Work Area Containment without Decontamination Unit**

Level 2 Containment may be applicable to HVAC system cleaning in any building use classification when mold or biological contamination is known to exist within the system. In cases when microbial amplification covers a surface area greater than 5 square feet, Level 3 Containment must be used. Level 2 Containment is the minimum level of containment appropriate to a healthcare facility. All of the Level 1 Containment requirements apply to Level 2 Containment areas. In addition, the following protective actions are required under Level 2 Containment strategies:

- Work Above Ceilings – Above ceiling work area must be completely isolated from occupied spaces within containment barriers utilizing 6-mil fire retardant polyethylene sheeting or equivalent. These barriers must be sealed airtight where they meet the ceiling, floor, and walls.
- Containment Area Floor – The containment must have a two-layer floor utilizing 6-mil fire retardant polyethylene or equivalent. The floor material must extend at least 6 inches (15.2 centimeters) up the containment side walls. The floor material must be sealed to side walls with two layers of duct tape in an airtight manner.
- Containment Area Access – A vertical cut in the containment side wall must provide access into the containment area. This vertical cut must begin no less than 6 inches (15.2 centimeters) from the floor and must be at least 5 feet (1.5 meters) long. The entrance must be entirely covered by two flaps (one on each side of the polyethylene).
- Negative Pressure – The containment area should be kept under negative pressure at all times to the degree feasible. Negative pressure must be sufficient to prevent migration of particulate material out of the containment area. Exhaust from the device providing negative pressure must be HEPA filtered. If this device does not exhaust directly outdoors, it must be possible to verify that there is no leakage through or around the HEPA filter.
- Dismantling – Interior surfaces of the containment enclosure must be wet-wiped or HEPA vacuumed before moving or dismantling the containment enclosure.

**Level 3 Containment - Work Area Containment with Single Chamber Decontamination Unit**

Level 3 Containment may be applicable to HVAC system cleaning in buildings where severe cases of microbial amplification or hazardous substances are known to exist within the HVAC system or indoor environment. Level 3 Containment is commonly the level of containment appropriate to healthcare facility cleaning projects, including those where microbial contamination may not exist. All of the Level 1 Containment and Level 2 Containment requirements apply to Level 3 Containment areas. In addition, the following protection actions are required under Level 3 Containment strategies:

- HEPA-filtered negative air machines may be utilized as a supplement to containment techniques described herein to control ambient airborne particulate levels.
- Decontamination Facility – A single chamber decontamination facility must be utilized in conjunction with the containment area. The decontamination chamber must be attached and sealed directly to the containment area. The decontamination chamber must be separated from the containment area by double flaps of 6-mil fire retardant polyethylene sheeting or equivalent. The flaps must be attached at

the top and one side. The decontamination chamber must utilize double flaps for its opening to the non-work area.

- Monitoring Requirements – Level 3 containment areas must be monitored for negative pressure on a continuous basis by using an instrument sensitive enough to detect a loss of negative pressure. Background monitoring for total particulate must be performed prior to set-up of containment to establish baseline airborne total particulate concentrations. It is recommended that monitoring also be conducted during set-up of containment. Real time monitoring for total particulate must be conducted on a regular basis to ensure that particulate is not escaping the containment. If airborne particulate levels exceed background levels, work must cease until airborne particulate levels are reduced to background levels and the cause of problem is found and corrected.

**Level 4 Containment - Work Area Containment with 2-Chamber Decontamination Unit**

Level 4 Containment may be applicable to HVAC system cleaning work sites harboring hazardous substances or those within a healthcare facility. All of the Level 1, Level 2, and Level 3 Containment requirements apply to Level 4 Containment areas. In addition, the following protective actions are required under Level 4 Containment strategies:

- Decontamination Facility – A decontamination facility as described for a Level 3 Containment area must be utilized, except that the decontamination facility must consist of two chambers. Each chamber must be constructed according to the requirements described for a Level 3 Containment area.

- Monitoring Requirements – Monitoring requirements described for a Level 3 Containment area must apply. In addition, the containment must have a constant recording pressurization monitor with an alarm.

**HVAC Components Engineering Controls**

Maintaining a pressure differential within HVAC system ductwork may not provide a satisfactory engineering control to prevent the migration of particles when cleaning certain system components such as air-handling units, control boxes, induction units, and other heating or cooling apparatus. Therefore, it is highly recommended that alternative engineering controls for cleaning activities on these HVAC system components be used. The type of engineering controls required for such components will vary depending on the size and type of component, the classification of building the HVAC system is located within, and the types of contaminants known to be present within the HVAC system.

An HVAC component with internal surface area being cleaned of not greater than 3 square meters (32.3 $ft^2$) and located within the occupied space must be cleaned utilizing a HEPA filtered contact vacuum and/or wet wiping. When an HVAC component of internal surface area greater than 3 square meters (32.3 $ft^2$) and located within the occupant space is being cleaned, the work area where the component is located must be placed into Level 2 Containment. However, if the minimum negative face velocity of the work area service opening in the component being cleaned is at least 100 feet/minute (30.5 meters/minute), then Level 2 Containment is not required.

In cases where the HVAC system component is known to contain severe microbial amplification or hazardous substances, or when the building being cleaned is a healthcare facility or other sensitive environment, isolation of the equipment from the occupant space must be maintained using Level 2 Containment at a minimum. Higher levels of containment may be necessary depending on the classification of building and contaminants known to be present.

## Equipment Redundancy

Loss of containment caused by equipment failure can be avoided or minimized by providing redundant equipment. Equipment redundancy is required on projects taking place within healthcare facilities as well as on projects where severe mold or biological growth or hazardous substances are known to exist within the HVAC system. When equipment redundancy is specified by the project plan, the following criteria must apply:

- Secondary equipment, which is equal or greater in capability, is to be staged on the production site creating redundant operations to meet the engineering, safety and containment minimum requirements. It is highly recommended that all secondary equipment meet or exceed the same requirements as the primary equipment. All equipment specified for redundancy purposes will be in the same location as the primary equipment and pre-tested for operation. Redundant equipment must be specified as either concurrent operation or non-concurrent operation.

- Under concurrent operation, the redundant equipment must be fully operational while the primary equipment is functioning. Loss of either piece of equipment should not alter the containment, engineering controls or safety protocols of the project to a point less than the minimum requirements.

- Under non-concurrent operation, the redundant equipment is not required to be operational while the primary equipment is functioning. The secondary equipment must be wired, contained, isolated, vented, secured, and fully prepared for immediate operation if failure of the primary equipment occurs.

In cases where the redundant equipment is connected to an emergency power source, the building owner or representative must approve the use of that power source.

# Chapter 2
# Particle Profiling (PP) Procedures

Purpose: The Particle Profiling Procedure is a screening tool which may be used to assess to what extent if any the HVAC system is contributing or introducing undesired particles to the indoor ambient air.

When properly applied and interpreted, this procedure can provide basic information for the investigator to better understand supply air particle concentration and composition (within the limitations of the collection procedure and lab analysis) of the conditioned (supply) air.

Overview: This sampling protocol establishes the amount of respirable (using laser particle counting technology) and countable (using microscopic analysis) particles in the return space (before filtration at the apparatus occurs) compared to the amount of particles distributed out of the supply ducts. This data is compared to the expected particle removal efficiency of the air filter. Results obtained from this procedure are interpreted by the investigator to determine if certain sources of contamination are likely originating from within the HVAC system and are subsequently contributing these undesired agents or particles to the indoor ambient air.

The protocol is a useful screening method that uses actual field measurements to assess the performance of the existing HVAC air filtration, and potential air by-pass as well as to assess the ability of the HVAC system to distribute certain undesirable particles into the indoor ambient air. Using the pre-cleaning data, the procedure can also be used as part of the final quality control/quality assurance plan to assess the effectiveness of cleaning efforts. The procedure is for use in general office environments. In the case of clean rooms, hospitals, critical care environments, and similar sensitive environments, modifications and more detailed enhancements should be made.

Individuals performing the procedure need to have a comprehensive knowledge of HVAC systems, environmental testing, data interpretation and associated HVAC components. In particular, the individual must have a comprehensive knowledge of air filter efficiency and outside air ventilation design to properly perform and interpret the data that is collected. It is highly recommended that the person or company conducting the procedure not be financially connected with any potential remediation company anticipating performing remediation or cleaning activities. In general, it is highly recommended the procedure be performed by a qualified and experienced indoor environmental professional (IEP) with experience in HVAC systems.

The Procedure includes the following components:

- **Visual Observations of the HVAC system:** The technician performing the procedure must observe the air-conditioning system interior for settled debris, air by-pass at the air filter bank and air by-pass in the return duct or equipment cabinet. The observations must be documented with notes and/or photo images.

- **Particle Measurements:** Particle measurements must be taken at the return air and supply air registers. A laser particle counter that has the ability to enumerate individual particle sizes and show a printout of the results must be used. The measurements must be plotted on a filter chart, which may be found in applicable ASHRAE documents (i.e., MERV test or dust spot tests).

- **Air Sampling:** Air samples using a fungal spore trap must be taken from the ambient air (inside and outside the building) and from the supply air. The fungal spore trap needs to be analyzed by a qualified laboratory. The analysis should include, at minimum, the type and quantity of fungal spores, man-made vitreous fibers (fibrous glass), and opaque particles.

- **Surface Sampling:** Surface samples using sticky tape must be procured from locations inside the HVAC system. A laboratory must determine if fungal germination is or has occurred by analyzing the samples.

- **Air Temperature and Relative Humidity Readings:** Temperature and humidity measurements must be obtained indoors and compared to requirements set forth in ASHRAE Standard 55.

Location of the outdoor air ventilation must be properly accounted for when using the procedure. Detailed requirements for the analytical procedures listed above are contained in the following sections.

**Particle Measurements**

Particle measurements should be taken using a 6-channel laser particle counter operating at a flow rate of 0.1 CFM.

Three (3) samples must be taken at the return air entering the air-handling unit. Samples must also be taken at approximately 50% of the supply air outlets. For more aggressive sampling, one (1) sample should be procured at a supply outlet during start up of the indoor fan, and one (1) sample should be taken while lightly tapping on the side of the duct.

The particle size range to be studied includes the following: 0.3, 0.5, 0.7, 1.0, 2.0, and 5.0 micrometers (µm). The coincidence error is less than 5% at $2 \times 10^6$ particles/cu. ft.

The particle counter must be properly prepared before sampling occurs. The following actions must be performed:

1. Check battery level to ensure unit does not become non-operational during sampling.
2. Program time and date to current settings.
3. Turn printer option on.
4. Turn machine on, attach purge filter, and run in concentration (CONCEN) mode for 1 minute. At the end of 1 minute, print the particle count taken with the purge filter on and stop the unit.
5. Replace the purge filter with the sampling probe.

The laser particle counter should be zero counted and purged each day prior to use (the manufacturer's instructions should be followed for this procedure. The laser particle counter should be factory calibrated and serviced in accordance with the manufacturer's recommendations (once a year).

When performing the sampling, the following procedures must be followed in sequence:

1. Set unit to desired number of samples (enough for a representative sample).

2. Set period to 1 minute.
3. Set hold time based on accessibility to sampling locations.
4. Enable print mode.
5. Set location to a representative number.
6. Place counter in an area representative of the return air.
7. Run sampler in auto mode for length of preprogrammed time.
8. Remove sampling probe and replace with isokinetic probe.
9. Set the number of samples equal to the number taken in the return air.
10. Set location to a representative number.
11. Sample in the supply ducts by placing the isokinetic tube into the register openings, a different register per sample.
12. Continue this for the duration of the sample.

The data collected may be used to calculate the percentage increase or decrease in particulate measured in the air. The calculations must be performed using the following formula:

$$\text{\% Increase or Decrease} = 100\left(\frac{\text{Supply Air}}{\text{Return Air}} - 1\right)$$

Once the calculations are completed, the data should be plotted on a modified ASHRAE filter efficiency performance chart.

**Air Sampling**

Air sampling for fungal spores must be performed using spore trap sampling procedures and a fungal spore trap. The pump used in this procedure must be operated at a properly calibrated flow rate as recommended by the cassette manufacturer.

Prior to sampling, a field calibration should be performed using a standard calibrated rotometer (with a cassette attached).

One (1) sample must be taken of the ambient indoor air. One (1) sample must be taken of the supply air. One (1) sample must be taken of the return air.

The following sampling procedure must be followed:

1. The fungal spore trap should be attached to the pump and the inlet cover or seal tape removed.

2. The sampling pump/cassette should be placed in the appropriate location at the return air, supply air and in the ambient air and operated for a period of time as recommended by the cassette manufacturer or as required to obtain the necessary results. Supply air samples should be obtained underneath a supply air vent in a manner that prevents mixing with ambient air, and should be located in an air stream that is operating at the same approximate static pressure as the pump discharge. Return samples should be obtained with the outside air accounted for in order to provide a true representation of filter performance.

Spores will be identified and enumerated within analytical limitations. Concentrations are reported in spores per cubic meter. Analysis shall be by direct microscopic analysis by a qualified laboratory.

**Surface Sampling**

Surface samples must be taken to determine if fungal amplification is occurring within the HVAC system. Samples must be taken using sticky tape mounted to a slide.

One (1) must be taken from the return duct. Two (2) samples must be taken from the air-handling unit. Two (2) samples must be taken from the supply plenum, or supply duct (depending upon accessibility).

The following procedures must be followed when performing the sampling:

1. Technician should wear clean examination gloves during the handling of all components (slides and tape).
2. The “sticky” tape should be impinged on the area to be sampled.
3. The tape should then be placed on a slide, properly labeled, and stored as not to cross-contaminate the samples.

The presence of spores and/or hyphal elements will be identified by direct microscopic analysis by a qualified laboratory.

**Conclusions**

The observations and data collected must be reviewed to determine if significant debris is present in the HVAC system, or if a fungal reservoir or other undesired contaminant (which can significantly affect the quality of the indoor air) exists in the HVAC system. Positive determinations indicate a need for cleaning. Likewise, if the analytical data demonstrates the HVAC system is introducing unwanted contaminants at undesired or unacceptable levels, then cleaning is necessary.

If temperature and humidity conditions exceed the ASHRAE acceptable range, this indicates the need for an engineering study to correct deficiencies.

# Chapter 3
# Guidelines for Constructing Service Openings in HVAC Systems

### Opening & Closing Externally Insulated Sheet Metal Air Ducts

When creating a service opening in externally-wrapped sheet-metal ducts, the external insulation should be cut on three sides, and folded out of the way, if the service opening is to be sealed with a closure panel. (If a permanent access door is to be installed in the service opening, all four sides of the external wrap should be cut and the insulation removed and discarded.) The sheet-metal should then be cut with industry-specific tools in such a manner as to leave the edges straight, free of burrs, bends, and deflections.

The closure panel must be of the same material and gauge (or heavier) as the duct wall to which it will be attached. If either dimension of the panel meets or exceeds 18", the panel must be fabricated with cross breaks.

When installing a closure panel, a bead of caulking/mastic must be applied around the edge of the opening, and the panel is then placed over the opening. Gasketing may be used in place of caulking/mastic. The panel must overlap the duct wall edges by a minimum of 1” on all sides. Secure the closure panel to the duct wall with screws or other mechanical fasteners 4" O.C. If an approved tape is to be used to seal the closure panel, rather than a sealant, the tape should be applied after the installation of the mechanical fasteners.

The external insulation should then be re-installed in its original position and fastened with staples and approved tape or mastic in such a manner that the vapor barrier is restored.

Drilled openings in the sheet metal duct from 1"-3" in diameter are approved for use. If the material used to close these service openings is common to the interior of the duct and subsequently, common to the airstream, those materials shall have a flame-spread rating of not over 25 without evidence on continued progressive combustion and a smoke-developed rating of not over 50.

### Opening & Closing of Lined Sheet Metal Air Ducts

When opening internally lined sheet-metal ducts, the openings should be made in such a manner as to provide straight sheet metal edges free of burrs, bends, or deflections. Discard the removed sheet-metal section as this will be replaced with a closure panel. The closure panel shall overlap the service opening by a minimum of 1" on all sides when installed.

Using a template 2" smaller in each dimension of the finished closure panel, mark the duct and cut the sheet metal. Discard the sheet metal. Using a sharp knife, cut out the piece of duct liner to match the size of the service opening and discard it as well.

When closing this opening, the closure panel shall have a new piece of duct liner glued and pinned to the closure panel. Use an approved coating or an approved duct liner adhesive meeting requirements of ASTM916 for all exposed edges created when the duct liner was cut. If the duct is lined with a rigid liner board insulation, it can be reused if it is deemed mechanically sound.

Apply a bead of sealant or mastic around the opening and mechanically fasten the closure panel to the duct wall with screws 4" O.C. Ensure that there are no breaks in the sealant. If an approved tape is to be used to seal the closure panel, rather than a sealant, the tape should be applied **after** the installation of the mechanical fasteners.

Drilled 1" service openings shall be closed with materials having a flame-spread rating of not over 25 without evidence of continued progressive combustion and a smoke-developed rating of not over 50. Any exposed fibrous glass edges within the duct should be sealed with no breaks or gaps in the insulation.

**Opening and Closing Fibrous Glass Ducts**

If the opening is to be less than the full height of the duct, the service openings should be made using either a straight knife or a shiplap tool to cut a converging 45 degree angle on all four sides. If the opening is to be full height, determine which of the longitudinal joints (top or bottom) will serve as the “hinge” for the opening.

Make converging 45 degree cuts along the remaining three sides. This section of the duct can either be lifted up or dropped down out of the way, dependent on the location of the cut. Along the corners of the duct the cuts should only be made through the facing of the duct.

Before re-installing the original section of duct, apply an approved ductliner adhesive meeting ASTM C 916 requirements to all cut edges of the section and the opening. Re-install the section to its original position. Seal all sides of the original cuts with approved closure methods and materials. If tape is to be used it shall meet the criteria of UL181A, part I or II, for fiber glass ductboard. The ductboard surfaces to which the tape will be applied must be clean and dry. Dust, dirt, oil, grease, and moisture may result in bonding failure. Follow the tape manufacturer’s recommendations.

**Opening & Closing Flexible Ducts**

Due to the nature of flexible ducting it is not possible or feasible to install service openings in it. The recommended methods of accessing flexible ducts are as follows:

> (1) Disconnect either or both ends of the flexible duct from the duct plenum or trunklines, the equipment, the grilles, or the registers. Upon completion of the cleaning/inspection, re-connect the flex duct to the metal collar with plastic closure straps or metal hose clamps. Seal the connection with tape compliant with UL 181B, Part I, or mastic compliant with UL 181B, Part II. Check for local compliance as codes vary from state-to-state.
>
> (2) Cut cleanly through the flexible duct to produce two separate openings for inspection/cleaning. Upon completion, insert the properly sized sheet metal connecting sleeve and reconnect the two ends. Complete the closure as in (1) above.
>
> (3) When replacing flexible ductwork, it is required that contractors follow all manufacturers’ instructions for proper installation.

**Important Information**

The guidelines shown above are not necessarily inclusive of all methods of service opening construction. The provisions of this Standard are not intended to prevent the use of any material, method or system not specifically addressed herein, provided that such material, method, or system meets the flame and smoke criteria of this Standard and all other criteria of locally adopted codes.

No matter the type of duct construction, it is important that service openings be constructed in a manner that facilitates a proper closure that meets the requirements set forth in the above Standard.

Contractors inexperienced in the actual physical creation of service openings are recommended to seek professional training prior to attempting any procedures described herein.

# Chapter 4
# International HVAC System Cleaning Resources

Several organizations around the world dedicate all or a portion of their efforts toward HVAC system cleaning. The knowledge and experience of these organizations is shared globally through such forums as the International Council on Ventilation Hygiene (ICVH) and NADCA.

The documents listed in this section encompass a portion of the most significant standards and guidelines related to HVAC system cleaning produced by industry worldwide. Their applicability may be limited to the nations or areas for which they were originally intended.

## Japan

**Japan Air Duct Cleaners Association (JADCA)**

JADCA Publications

- *JADCA Technological Standard, 1990.*
- *The Point of Diagnosis and Evaluation of Air Duct Cleaning, 1991.*
- *The Actual State and the Cleaning Management of the Duct System, 1992.*
- *The Guide to Cleaning and Management of the Kitchen Exhaust Duct System, 1995.*
- *The Special Report, "Duct Contamination," 1997.*
- *Textbook of Certification Program for Air System Cleaning Specialists, 1999.*

JADCA Research Reports

- JADCA-01 *Methods to Evaluate the Duct Cleaning Efficiency, 1997.*
- JADCA-02 *Light Transmission Measurement Method, 1997.*
- JADCA-03 *Measurement of Dust Generation, 1997.*
- JADCA-04 *Field Investigation on the Effects of Duct Cleaning on Indoor Air Quality with Measured Results of TVOC and Perceived Air Quality, 1997.*

Related Laws in Japan

- Ministry of Health and Welfare, The Laws for Maintenance of Sanitation in Buildings, 1970.

## Sweden

- *Checking the Performance of Ventilation Systems*, The Swedish National Board of Housing, Building and Planning. General Guidelines 1992:3E.

## United Kingdom

- *TR17 Guide to Good Practice: Cleanliness of Ventilation Systems*

# United States of America

**National Air Duct Cleaners Association (NADCA)**

- *Introduction to HVAC System Cleaning Services (Guideline), 2001.*
- *General Specifications for the Cleaning of Commercial Heating, Ventilating and Air Conditioning Systems, 2001.*

## DISCLAIMER

The Standards Committee of the National Air Duct Cleaners Association (NADCA) developed NADCA ACR 2006. It is intended to establish the minimally acceptable criteria for Heating, Ventilation and Air Conditioning (HVAC) hygiene assessments, project design, cleaning, and verification. This standard is based on the collective experience of members of the industry, but is not intended to be either exhaustive or inclusive of all pertinent requirements. The information provided in this standard is offered in good faith and believed to be reliable, but is made WITHOUT WARRANTY, EXPRESSED OR IMPLIED, AS TO THE MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR ANY OTHER MATTER.

The provisions are not intended to be directed to any particular product or contractor, nor are they claimed to satisfy all current legal, health and safety, or performance requirements related to contractual relationships for Heating, Ventilation and Air Conditioning (HVAC) system cleaning projects. Following this standard does not guarantee compliance with any regulation, nor safe, satisfactory, or complete performance of HVAC system cleaning. Users are cautioned that the existing HVAC system design, installation, maintenance history, building design, occupancy and maintenance play a significant role in managing indoor air quality. Thus, users of this document should understand the limitations with use of this document in an attempt to mitigate indoor environmental problems. The information upon which this standard is based is subject to change, which may invalidate any or all of the information contained herein.

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It should be noted that this standard does not specifically address the protocols for service when potentially hazardous, regulated materials are likely to be present in HVAC systems. Such potentially hazardous, regulated materials include, but are not limited to, asbestos, lead and other chemical and biological contaminants. This standard does not address such situations for two reasons. First, the worker safety and public safety aspects of operations involving hazardous materials are, in many cases, governed by legal requirements imposed by the Occupational Safety and Health Administration, the United States Environmental Protection Agency and various state and local agencies. Second, unless HVAC system cleaners are engaged specifically to perform hazardous material decontamination, the building owner and/or occupant should bear responsibility for any consequences of encountering unexpected hazardous materials.

## *FORM TO REQUEST FORMAL INTERPRETATIONS OF NADCA STANDARD ACR 2006*

**Mail to: Chairman, Standards Committee**
**National Air Duct Cleaners Association**
**1518 K Street, NW**
**Suite 503**
**Washington, DC 20005**
**PHONE (202) 737-2926**
**FAX (202) 347-8847**

*NAME:* ______________________________ *E-MAIL:* ______________________________

*COMPANY:* ______________________________________________________________

*ADDRESS:* ______________________________________________________________

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*PLEASE INDICATE ORGANIZATION REPRESENTED, IF ANY* ______________________________

*Section / Paragraph* ______________________________________________________

*QUESTION (attach another sheet if necessary):*

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