ACTION AIR CONDITIONING & REFRIGERATION · TECHNICAL BRIEF NO. 1

HVAC SYSTEMS & MOLD

Cause, effect, remediation and prevention in hot-humid climates — a field-study and standards review for the Tampa Bay market.



INDOOR RELATIVE HUMIDITY — TARGET, CAUTION, FAILURE

Prepared for: Action Air Conditioning & Refrigeration | Real Duct Cleaning LLC

Licenses: CAC1818409 | CAC1822457

Clearwater, Florida · actionacr.com · realductcleaning.com

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EXECUTIVE SUMMARY

MOLD IS A MOISTURE-CONTROL FAILURE, NOT A CLEANING FAILURE

Mold spores are everywhere, mold food is everywhere, and mold grows happily at the same temperatures people do. Of the four conditions fungal growth requires, only one is controllable in an occupied building: **moisture**. That single fact determines everything in this document.

In a Florida cooling system, moisture is not an accident — it is a designed output. Humid air crossing a 40–50 °F evaporator coil condenses by design. The coil, the drain pan and the plenum are permanently damp surfaces collecting airborne organic dust. When the system cycles off, that moisture re-evaporates and whatever has colonized those surfaces is distributed to every supply register in the building. The HVAC system is therefore both the primary dehumidifier and, when it fails, the primary distribution mechanism for contamination.

The failures that let this happen are almost never exotic. Florida Solar Energy Center field work found uncontrolled airflow in **69 of 70** small commercial buildings tested, with measured duct leakage averaging roughly seventy times the SMACNA standard. Equipment oversizing shortens run cycles below the point where latent removal becomes effective. Closed doors without return pathways depressurize the house and pull 80 °F-dewpoint outdoor air through wall cavities onto cold gypsum. None of these are visible on a walkthrough, and none of them are fixed by cleaning ducts.

The health stakes are well established. Meta-analyses across the international literature consistently associate

building dampness and mold with 30–70% increases in asthma exacerbation, wheeze, cough, respiratory infection, allergic rhinitis and eczema, with the evidence for asthma exacerbation in children strong enough that reviewers describe it as suggestive of causation.

THE OPERATING PRINCIPLE

Remediation without source correction is a scheduled repeat visit. Every remediation scope in this brief assumes the moisture pathway has been identified, measured and corrected first — and that the correction has been verified with instruments, not opinion.

PART 1

CAUSE — THE BUILDING SCIENCE OF HVAC-RELATED MOLD

1.1 THE FOUR REQUIREMENTS, AND THE ONLY ONE YOU CAN CONTROL

Fungal growth requires spores, food, suitable temperature and moisture. The Florida Solar Energy Center's framing of the problem is the most useful one for field work, because it eliminates three of the four as control strategies:

- **Spores** range from roughly 3 to 40 microns and are ubiquitous. There is no practical, reliable or cost-effective way to remove them from occupied space.
- **Food** is any carbon-bearing substance. Skin oil transferred to stainless steel is sufficient. Soap residue left after a good cleaning is sufficient. Paper-faced gypsum is a preferred substrate.
- **Temperature** ranges that support vigorous growth overlap almost exactly with the range humans find comfortable, and refrigerator temperatures are not cold enough to stop it.
- **Moisture** is the sole controllable variable — and conveniently, humans prefer humidity levels below the threshold most molds require.

1.2 WATER ACTIVITY: THE NUMBER THAT ACTUALLY MATTERS

Mycologists describe the requirement as *water activity* — the equilibrium relative humidity of the air in balance with a material at a given moisture content. The great majority of mold species require water activity equivalent to roughly **70% RH or higher** at the material surface. Serious, large-scale indoor outbreaks almost always occur where porous cellulose materials have been kept genuinely wet by liquid water or sustained condensation.

This is why air relative humidity and surface conditions must be considered separately. A room can read 55% RH while the back face of gypsum behind vinyl wall covering sits well above 90% because humid air is condensing on it. The bulk air measurement is necessary but not sufficient.

> **FIELD IMPLICATION**
>
> A hygrometer reading of 55% in the hallway does not clear a building. Surface temperature and the direction of air movement across assemblies determine where condensation actually lands. Infrared and pressure diagnostics find what a humidity reading cannot.

1.3 THE COIL, PAN AND PLENUM MECHANISM

During operation the evaporator coil runs roughly 40–50 °F. Humid air crossing it condenses; condensate is supposed to leave via the pan and drain line. In practice the pan is a permanently damp reservoir that also collects filtered-through dust and organic debris — a near-ideal biofilm habitat. On the off cycle the coil warms and residual moisture evaporates back into the airstream, carrying whatever has established on the coil, pan or plenum surfaces out through every supply run.

Two consequences follow. First, the system distributes contamination faster than any other mechanism in the

building, which is why EPA guidance is explicit that a system suspected of contamination should not be operated. Second, biofilm on the coil acts as thermal insulation and an airflow restriction, so the hygiene problem and the performance problem are the same problem.

1.4 OVERSIZING AND CYCLE LENGTH

Cooling equipment does two jobs: sensible cooling (temperature) and latent cooling (moisture). They do not proceed at the same rate. FSEC test data show that moisture removal does not reach full capacity for approximately the **first three minutes** of each on-cycle — the coil must get cold and stay cold before meaningful condensation occurs.

An oversized system satisfies the thermostat before that point. The result is a home that is cool and clammy: sensible load met, latent load untouched. A correctly sized system running long, steady cycles under design load removes gallons of water per day. FSEC's illustration of the effect is blunt — a properly matched two-ton unit will out-dehumidify a four-ton unit in the same house, despite the four-ton machine carrying twice the nameplate moisture-removal rating.

This is compounded at higher thermostat settings, where run-time fraction drops further. Oversizing and a 78 °F setpoint are a bad combination in July.

1.5 FAN MODE AND RE-EVAPORATION

Continuous blower operation (*fan ON*) re-evaporates coil condensate back into the conditioned space before it can drain away. FSEC ran the same house in each mode for at least a week at a time and measured the difference:

INDOOR SETPOINT	AVG RH — FAN AUTO	COMPRESSOR RUN-TIME FRACTION	AVG RH — FAN ON
80 °F	55%	0.27	65%
77 °F	60%	0.35	70%
76 °F	67%	0.60	70%
71 °F	74%	0.80	75%

Source: Florida Solar Energy Center test data, after Khattar, Swami & Ramanan, "Another Aspect of Duty Cycling: Effects on Indoor Humidity," FSEC-PF-118-87, ASHRAE, 1987. System operated alternately in each mode for at least one week.

Two things in this table deserve attention on every service call. First, the fan-ON penalty is **5–10 percentage points of RH** across the range — enough on its own to move a house from safe to marginal. Second, and less intuitive, indoor RH *rises* as setpoint drops. At 71 °F the house is running 74% RH even in AUTO. Colder surfaces plus a lower absolute-moisture ceiling do not equal a drier house.

FSEC also notes that many air handlers run the blower for one to three minutes after the compressor stops, which re-evaporates coil moisture for the same reason on a smaller scale. Where maximum dehumidification is the goal, that delay can be disabled so blower and compressor stop together.

> **COUNTER-CONSIDERATION**
>
> Continuous fan operation is sometimes specified for filtration, ventilation distribution or room-to-room temperature balance. Those are legitimate goals. The point is not that fan ON is always wrong — it is that in a humid climate it carries a measurable, quantified humidity cost that must be paid for somewhere else, usually with supplemental dehumidification.

1.6 UNCONTROLLED AIRFLOW: THE FOUR FAILURE MODES

FSEC defines uncontrolled airflow (UAF) as air moving across the building envelope or between zones where the pathway, direction or origin is unknown, unspecified or unintended. It has four primary forms:

1. Duct leakage

Impact depends on where the leak sits relative to the building's air and thermal barriers. Leaks inside both barriers waste little and cause no added infiltration. Leaks inside the air barrier but outside the thermal barrier waste energy without driving infiltration. Leaks outside *both* barriers — the standard Florida vented-attic condition — drive significant energy waste *and* significant infiltration of hot, humid air.

2. Restricted return air

Supply to every room, return in the hallway only. Close the doors and the bedrooms pressurize while the central zone depressurizes. The pressurized rooms push conditioned air out through the ceiling and walls; the depressurized zone pulls attic and outdoor air in. Suspended t-bar ceilings are extremely leaky and make this far worse in commercial space. Where a ceiling plenum is used as the return, fire-wall crossover openings are frequently undersized — and fire dampers sometimes fail closed.

3. Exhaust and intake imbalance

Common in restaurants, hotels and recreation facilities, where large exhaust fans are not matched by adequate make-up and outdoor air. The building then operates at sustained negative pressure and mines humid air from every available crack.

4. Leaky shells and over-vented buffer zones

Excessively ventilated buffer zones allow condensation on ductwork and piping, producing wet ceilings and growth above the finished surface where nobody looks.

1.7 SIX ROOT CAUSES BEHIND UNCONTROLLED AIRFLOW

FSEC attributes UAF to design failure, poor workmanship, HVAC commissioning failure, operations and maintenance failure, materials degradation, and building retrofits. Some of the most extreme cases in the 70-building dataset were caused by tenant build-outs that moved walls and blocked return pathways — which is why commissioning matters as much on retrofit as on new construction.

1.8 PRESSURE DIRECTION AND THE ENVELOPE

In a hot-humid climate the outdoor-to-indoor vapor pressure difference is far larger than anything a cold-climate building sees, and it pushes inward year-round. When a house is depressurized, that humid air is drawn through the

small distributed pathways every envelope contains — entering high at an exterior fixture, travelling through the wall cavity, exiting low at an interior outlet.

Along that path it contacts air-conditioned gypsum. Florida summer outdoor dewpoints above 80 °F are routine. Cold wallboard behaves exactly like a glass of iced tea carried outside: it condenses moisture out of the air moving across its back face. The moisture accumulates in the board, and the paper facing is preferred mold food.

FSEC modelling of combined heat, moisture and air transport shows that a pressure difference of only **2 pascals** determines the outcome — and that it is the *direction* of the gradient, not its magnitude, that matters. Building Science Corporation's guidance for hot-humid new construction independently arrives at the same target: maintain approximately 2–3 Pa positive pressure indoors, air-seal the enclosure, and locate ductwork inside conditioned space where possible.

WHY THIS IS THE DIFFERENTIATOR

Two pascals is roughly one fifty-thousandth of an atmosphere. It cannot be felt, seen or guessed. It can only be measured — which means a contractor with a manometer and a blower door is operating in a category that a contractor with a flashlight cannot enter.

Common causes of house depressurization

- Exhaust fans — bath, kitchen, attic, crawlspace
- Clothes dryers
- Supply duct leaks outside the envelope
- Insufficient return pathways when interior doors close
- Unbalanced commercial exhaust with missing or undersized make-up air

1.9 VINYL WALL COVERING: THE HIDDEN CASE

Impermeable interior finishes are a severe risk in this climate. Moisture driven inward accumulates in the gypsum behind the covering and cannot be removed by the air conditioning system, because the vinyl blocks the drying path. The diagnostic signature is distinctive: **pink to yellow staining** on the face of the covering, indicating a bloom on the wallboard behind it. In advanced cases the board becomes soft and structurally compromised. This is a pressure-diagnostics problem, not a surface-cleaning problem.

1.10 CONDENSATE TRAP AND DRAIN FAILURES

Condensate traps are frequently disconnected, broken or improperly configured. A dysfunctional trap allows air to enter the drain line at high velocity, which causes ponding in the pan, overflow into the air handler cabinet, and splattering of standing water onto interior surfaces. The result is degraded dehumidification performance combined with wetted air handler and duct surfaces — a fertile environment for growth, created by a five-dollar fitting.

1.11 POROUS MATERIALS INSIDE THE SYSTEM

EPA is unambiguous on internally lined ductwork: if the interior insulation becomes wet or moldy it must be **removed and replaced**, because it cannot be effectively cleaned. EPA further notes there are **no EPA-registered antimicrobial**

products or biocides approved for use on lined ductwork. Any proposal to spray a lined system and call it remediated is outside the approved use of the product.

PART 2

FIELD STUDY EVIDENCE FROM FLORIDA BUILDINGS

Everything in Part 1 is theory until it is measured. The following comes from instrumented field work in Florida buildings — the same climate, the same construction practices and the same trade base we operate in.

2.1 THE 70-BUILDING COMMERCIAL STUDY

Cummings and Withers at the Florida Solar Energy Center tested uncontrolled airflow in 70 small central-Florida commercial buildings ranging from 880 to 22,500 square feet — a size band representing roughly 90% of all US commercial buildings by count.

69 of 70

Buildings found with significant uncontrolled airflow. Exactly one building tested clean.

341

Average duct leakage, CFM25 per 1,000 sq ft of floor area (46 buildings measured).

70×

That leakage rate expressed against the SMACNA duct leakage standard. Roughly 3× typical Florida residential.

The documented consequences were not subtle: high utility bills, thermal discomfort, elevated indoor humidity, mold and mildew growth, moisture damage to building materials, transport of pollutants into occupied space, and backdrafting of combustion equipment.

2.2 RESTAURANTS AND EXHAUST IMBALANCE

Of eight restaurants tested, **three had no make-up air or outdoor air provided at all**. In the remaining five, combined make-up and outdoor air totalled only **65% of exhaust flow**. These buildings ran at substantial sustained negative pressure, and the documented outcomes read like a punch list of everything that can go wrong at once: elevated indoor humidity, moisture accumulation in walls, wall mold and mildew growth, drywall damage, wallpaper delamination, uncomfortable room temperatures, extinguished pilot lights, backdrafting of combustion appliances, flame roll-out from gas water heaters, and sewer gas drawn in through drain lines.

In one case the depressurization was severe enough that exterior doors had to be signed asking patrons to pull hard, because people assumed they were locked.

Documented cases

BUILDING	MEASURED PRESSURE	OUTCOME
Restaurant, 8 months old	−3 to −17 Pa	Pressure cycled with air handler staging. Wall mold and mildew, wallpaper delamination, water heater backdrafting and flame roll-out.
Golf club house, 10 months old	−6 Pa	Kitchen and locker room exhaust pulled humid attic air down through wall assemblies, where it condensed in cool wall materials. 40% of the wallpaper had to be removed.
Restaurant, filters never serviced	−25 Pa	Nine months after a contractor demonstrated positive pressure with a smoke pencil, caked filters had choked make-up and outdoor air while exhaust ran at full flow. Water heater backdrafting, pilot outage, sewer gas intrusion. **Cleaning the filters restored the building to −2 Pa.**

Source: Cummings & Withers, FSEC. Full restaurant dataset in ASHRAE Transactions Vol. 102 Pt. 1 (1996).

> **THE MAINTENANCE ARGUMENT, QUANTIFIED**
>
> A 23-pascal swing in whole-building pressure caused by nothing more than dirty filters is the single best argument for a maintenance agreement that anyone in this trade has ever measured. It also demonstrates that a commissioning result decays — a building verified correct at handover is not verified correct nine months later.

2.3 WHEN THE PAPERWORK SAYS ONE THING AND THE BUILDING DOES ANOTHER

Three findings from the same body of work are worth keeping in mind whenever a submittal or a test-and-balance report is offered as proof that a system is correct.

Outdoor air that never reached outdoors

In a five-story government office building with eleven air handlers, outdoor air was verified by pitot traverse. On the first floor, one outdoor air duct stopped one inch short of its exterior grille — roughly **70% of the measured "outdoor air" was actually being pulled from the mechanical room**. On the second floor, two outdoor air ducts ran to exterior walls and through plywood panels, behind which there were no grilles at all, only solid brick. The traverse had been faithfully measuring air leaking in from indoors.

Crossover openings undersized by a factor of three

In the same building, fire walls restricted return air through a ceiling plenum. The crossover windows intended to allow return flow were undersized threefold, producing zone pressures ranging from **−8 to +17 Pa** — simultaneously pushing air out of one part of the building and pulling it in elsewhere. The test-and-balance report did not detect or report it.

Why standard test-and-balance misses this

Conventional TAB practice does not typically measure duct airtightness, and does not account for duct leakage when balancing. Flow hood and pitot readings are taken at grilles and inside ducts — not at the building air boundary — so leakage between the measurement point and the outdoors is invisible to the method. FSEC's worked example:

exhaust specified at 40 CFM per guest room across 200 rooms, grille readings averaging 27 CFM, TAB technicians correctly conclude exhaust is short and increase fan speed to hit 40 at the grille. Total exhaust from the building rises to roughly 11,000 CFM against a design 8,000, and the hotel moves from **+1 Pa to −6 Pa**. Every reading was accurate. The conclusion was wrong.

2.4 MANUFACTURED AND SITE-BUILT HOUSING

Building America researchers working with FSEC investigated moisture failures in Florida manufactured housing in the late 1990s. Conditions in the worst homes were severe enough that investigators could push their fingers through saturated drywall. Whole-house diagnostics identified the dominant moisture source as **humid air drawn in through leaky ducts** located beneath the floor or in uninsulated, vented attics.

Over 39 factory visits across six manufacturers, researchers measured duct leakage in 101 houses representing 190 floors. Most systems had been sealed with mastic; about a third had been sealed with tape. The finding that matters to installers:

MASTIC VS. TAPE

The ≤6% total duct leakage target was met by a substantially higher proportion of mastic-sealed systems than tape-sealed systems. Researchers observed that mastic produced a markedly more durable seal. Separately, FSEC identifies **tape adhesive failure under high temperature** as the most common materials-related cause of duct leakage in the field — a system that passes at commissioning and fails two summers later.

2.5 VACANT AND SEASONAL PROPERTIES

FSEC, under a study sponsored by Florida Power & Light, tested strategies for controlling humidity in unoccupied Florida homes. Two approaches performed well:

1. **Timed dehumidification.** Run a dehumidifier on a timer for three to four hours daily, ideally draining condensate to a sink, with the cooling system off and interior doors left open.
2. **Early-morning deep cycle.** Program the thermostat to 74 °F between 3:00 and 6:00 AM and 85 °F for the remainder of the day. Continuous operation during those hours drives coil temperatures low enough for effective moisture removal. This worked across a majority of homes and a wide range of weather — *provided significant duct leakage had been repaired first*.

Given the snowbird and seasonal-rental share of the Pinellas market, this is a directly billable service offering, and the qualifier at the end of the second strategy is the up-sell.

PART 3

EFFECT — HEALTH, EQUIPMENT AND BUILDING FABRIC

3.1 THE HEALTH EVIDENCE BASE

The literature on dampness and health is unusually consistent for an environmental health question, and it is worth knowing precisely what it does and does not establish.

The 2004 US Institute of Medicine review found sufficient evidence of association between dampness-related exposures and upper respiratory tract symptoms, cough, wheeze and asthma exacerbation, plus sufficient evidence linking mold exposure to hypersensitivity pneumonitis. The 2009 WHO indoor air quality guidelines reached broadly parallel conclusions.

Subsequent reviews and meta-analyses have reinforced and extended this. Mendell and colleagues, reviewing the epidemiologic evidence through 2009, found dampness or mold consistently associated with asthma development and exacerbation, current and ever-diagnosed asthma, dyspnea, wheeze, cough, respiratory infection, bronchitis, allergic rhinitis, eczema and upper respiratory symptoms — in allergic *and* non-allergic individuals — with the evidence for asthma exacerbation in children strong enough to suggest causation. A separate systematic review and meta-analysis concluded that residential dampness and mold are determinants of *developing* asthma, with visible mold and mold odor pointing toward mold-related causal agents.

30–70%

Typical increase in prevalence of dampness-associated respiratory and allergic outcomes reported across meta-analyses.

21%

Share of US asthma cases estimated attributable to housing dampness and mold, if the reported associations are causal.

$17B

Upper estimate of annual US health-related cost of dampness and mold for asthma morbidity and mortality alone.

Estimates additionally include roughly $3.7B annually for allergic rhinitis and $1.9B for acute bronchitis. Sources: Lawrence Berkeley National Laboratory IAQ Science summary; Fisk, Lei-Gomez & Mendell (2007); Mudarri & Fisk (2007).

CDC/NIOSH summarizes the workplace picture in similar terms: time spent in damp buildings is associated with respiratory symptoms and infections, development and worsening of asthma, hypersensitivity pneumonitis, allergic rhinitis and eczema — and notes that individuals already sensitized to mold may react to trace amounts.

WHERE THE EVIDENCE STOPS

The same reviews are candid about limits. The specific agents responsible — particular molds, bacteria, or organic chemicals — remain uncertain, and measured microbiologic factors in dust showed only limited and partly contradictory associations. Reviewers concluded that current evidence **does not support measuring specific indoor microbiologic factors to guide health-protective action**. Visible dampness and mold odor remain the actionable signals. This matters for how we talk to customers: the defensible claim is about moisture control, not about spore counts.

3.2 ALSO TRUE, AND WORTH SAYING PLAINLY

There is not full consensus in the medical community on the health consequences of mold exposure, and the topic has attracted considerable inflammatory coverage. Serious disease from common environmental fungi is uncommon in people with normally functioning immune systems. Individuals with compromised immunity, asthma, allergies or other lung disease should consult a physician before disturbing mold growth. Saying this out loud costs nothing and buys credibility with the customers most likely to check.

3.3 EQUIPMENT AND ENERGY EFFECTS

Biological fouling on the evaporator coil is simultaneously a hygiene problem and a thermodynamic one. Biofilm insulates the heat transfer surface and adds airflow resistance, which reduces capacity, extends run times, and — because a struggling coil dehumidifies less effectively — feeds back into the moisture problem that created it.

The clearest quantification comes from a field study of coil-irradiation UVGI in a hot, humid climate, which measured the following over ten months of operation:

- Overall coil thermal conductance increased approximately **10%**
- Air-side pressure drop across the coil decreased approximately **13%**
- Fan energy consumption fell approximately **9%**
- Improvement was most rapid during the first month after intervention

Laboratory work on particulate fouling shows the same relationship from the other direction, with measured increases in air-side pressure drop ranging from single digits to over 200% depending on the coil and filter combination.

3.4 BUILDING FABRIC EFFECTS

The damage pathway documented in the Florida field studies runs: pressure imbalance → humid air through the assembly → condensation on cool interior sheathing → moisture accumulation in gypsum → growth on the paper facing → structural degradation of the board. Observed endpoints include softened or "mushy" wallboard, wallpaper and vinyl covering delamination, wet ceilings from condensation on ductwork in over-vented buffer zones, and staining that becomes visible only after the assembly is already compromised.

THE CONNECTED ARGUMENT

Health, energy and building damage are not three separate sales conversations. They are three readouts of one measurable condition: uncontrolled moisture. A diagnostic that quantifies the moisture pathway addresses all three at once, which is why diagnostics — not equipment — should anchor the offering.

3.5 THE RE-ENTRAINMENT EFFECT

Worth stating explicitly because it drives urgency. Growth established on a coil, in a drain pan or on plenum surfaces is not contained to the mechanical room. Every cycle distributes it to every conditioned space served by the system. Ceiling growth above a return plenum is drawn directly into the air path. A localized moisture failure in one closet becomes a whole-building exposure the moment the blower runs — which is the reasoning behind EPA's instruction not to operate a system known or suspected to be contaminated.

PART 4

REMEDIATION — THE GOVERNING STANDARDS

Three documents define the standard of care. None of them is a statute in Florida, but all three are routinely referenced in contracts, insurance requirements and litigation — which makes them the practical benchmark for what "done correctly" means.

4.1 THE GOVERNING DOCUMENTS

DOCUMENT	SCOPE AND RELEVANCE
US EPA Mold Remediation in Schools and Commercial Buildings; Mold Course Ch. 2 & 5; A Brief Guide to Mold, Moisture and Your Home; Should You Have the Air Ducts in Your Home Cleaned?	Federal guidance. Establishes area-based tiers, containment and PPE expectations, and the specific HVAC remediation sequence. Free and citable to homeowners.
ANSI/IICRC S520-2024 Standard for Professional Mold Remediation, 4th edition	The consensus professional standard, superseding the 2015 third edition. Defines contamination Conditions, containment, and post-remediation verification.
ACR, The NADCA Standard 2021 edition (free download) and 2025 edition	The HVAC-specific standard for assessment, cleaning and restoration. Defines minimum performance and procedural requirements and verification of cleanliness. Source removal is doctrine.

4.2 CLASSIFYING THE JOB: TWO FRAMEWORKS

EPA tiers by affected area — under 10 sq ft, 10 to 100 sq ft, and over 100 sq ft — each with its own containment and PPE expectations. S520 classifies by fungal condition rather than size:

- **Condition 1 — Normal fungal ecology.** Fungi present at levels and genera expected in an unaffected building. No remediation required. This is also the defined *goal state* of any remediation project.
- **Condition 2 — Settled spores.** Contaminated primarily by settled spores originating from a Condition 3 area or external source, without active colonization of the surface.
- **Condition 3 — Actual growth.** Visible growth on surfaces or materials, active or dormant. Triggers the full protocol.

ESCALATION TRIGGERS

EPA and IICRC guidance converge on professional remediation when: affected area exceeds 100 sq ft; **the HVAC system is involved**; or occupants include immunocompromised individuals, infants, or people with respiratory conditions. HVAC involvement escalates the job regardless of square footage. EPA states that HVAC remediation should be performed only by professionals experienced with HVAC systems.

4.3 THE EPA HVAC REMEDIATION SEQUENCE

1. Do not operate the system. Running a contaminated system distributes contamination building-wide.
2. Establish containment of the area served by the ventilation system. Seal all intakes and supply vents with plastic and tape.
3. Maintain negative air pressure in the work area.
4. Bag and remove contaminated porous materials — including wet or moldy internal duct liner, which cannot be effectively cleaned.
5. Clean salvageable non-porous materials by HEPA vacuum or damp cloth with detergent solution.
6. Dry all items promptly.
7. Consult duct cleaning guidance before adding duct cleaning to the scope.

Worker protection per EPA guidance: respirators worn until personnel reach uncontaminated area; disposable respirators discarded, reusable respirators bagged for cleaning; full PPE where warranted, including protective clothing with head and foot coverings and all gaps sealed, and full-face or powered air-purifying respirators with HEPA filtration.

4.4 WHAT CHANGED IN S520-2024

The fourth edition is directly useful to us competitively, because it hardens the standard against exactly the shortcuts that undercut honest pricing.

- **Source removal is emphasized more strongly than in any prior edition** as the primary method of remediation.
- The standard **strongly advises against spraying mold-contaminated areas with chemicals, disinfectants or other biocides** without first physically and completely removing the mold and thoroughly cleaning the surfaces — on the grounds that doing so conceals the underlying problem.
- Section 9.1.7 addresses ozone gas and other antimicrobial devices, advising that these **should not be relied upon as primary remediation tools**.
- The standard assumes that determining and correcting the underlying cause is the responsibility of the property owner or their agent, not the remediator — though the owner may contract that work separately. *This is precisely the gap a diagnostic-led HVAC contractor is positioned to fill.*

4.5 VERIFICATION

Post-remediation verification confirms return to Condition 1 before containment is removed. Typical project durations run 2–5 days for a Condition 2 job under 100 sq ft, and 1–3 weeks for extensive Condition 3 work involving

structural materials and HVAC systems.

EPA's position on verifying duct cleaning is that a thorough visual inspection is the best verification available, and that homeowners should require correction of any deficient item. NADCA's ACR defines cleanliness in specific, measurable terms rather than by appearance alone.

INDEPENDENCE MATTERS

Best practice on significant projects is for post-remediation verification to be performed by a third party rather than the remediating contractor. Where we perform remediation, recommending independent clearance costs us nothing and removes the single strongest objection a skeptical customer can raise.

4.6 DUCT CLEANING: WHEN EPA ACTUALLY SAYS TO DO IT

EPA does not blanket-recommend routine duct cleaning for all homes, and states that evidence linking duct cleaning to improved health in typical homes is inconclusive. It *does* specifically recommend cleaning when:

- There is substantial visible mold growth inside hard-surface ducts or on other HVAC components
- Ducts are infested with vermin
- Ducts are clogged with substantial deposits of dust or debris, or particles are actually being released into the space from supply registers

EPA also warns that poor-quality cleaning can create indoor air problems: an inadequate vacuum collection system can release more contaminants than leaving the ducts alone, and an untrained provider can damage ducts or components. And EPA tells homeowners to **ask the provider to show them any mold or biological contamination claimed to exist**.

TURN THE CONSUMER-PROTECTION LANGUAGE INTO A SALES ASSET

That last instruction was written to protect homeowners from our industry. Adopting it voluntarily — borescope photography before and after, documented and handed over on every job — converts EPA's warning into our verification protocol. The contractors it was written about cannot follow us there.

PART 5

PREVENTION — DESIGN, INSTALL AND SERVICE PROTOCOL

5.1 TARGET VALUES

PARAMETER	TARGET	BASIS
Indoor relative humidity	Below 60%; ideally 30–50%	EPA. Below 50% also suppresses dust mites.
Summer daytime RH, AC running	Should not routinely exceed 55%	FSEC. Exceeding it regularly indicates duct leakage or an equipment fault — oversizing, improper charge, or low airflow across the coil.
Surface water activity	Sustained below 70%	Threshold for the majority of mold species.
Building pressure vs. outdoors	Slightly positive; ~2–3 Pa	FSEC; Building Science Corporation. Direction matters more than magnitude.
Pressure across closed interior doors	2 Pa or less	FSEC airflow standard.
Shell airtightness (commercial)	4–8 ACH50	FSEC. Tighter risks extreme pressure imbalance from unbalanced flows; looser makes flow direction uncontrollable.
Total duct leakage	≤6%	Building America target; achieved far more reliably with mastic than tape.
Return transfer area, closed doors	50 sq in free area per 100 CFM supply	FSEC. Increase ~40% (to ~70 sq in per 100 CFM) where grilles are fitted, to offset their resistance.
Peak-load run cycles	20–30 minutes	Correctly sized equipment; latent removal requires roughly 3 minutes to reach full capacity.
UV-C irradiance at coil	50–100 µW/cm²	ASHRAE. Equivalent to roughly 7.5 lamp watts per sq ft of coil face area — a spec that can be checked on a submittal.

5.2 DESIGN AND INSTALLATION

- **Size by Manual J, not by square footage.** Rules of thumb produce oversizing, and oversizing is the most common

and least visible cause of humidity failure in this climate.

- **Specify variable-speed air handling with enhanced dehumidification modes.** Starting the blower at lower speed each cycle improves moisture removal, particularly at part load, and variable-speed motors draw substantially less power per unit of airflow than standard PSC motors.
- **Seal with mastic and fabric mesh, not tape.** Durability over the life of the building is the objective, and tape adhesive fails under sustained high attic temperature.
- **Locate ductwork inside the conditioned envelope where possible.** Where that is not possible, insulation levels and attic strategy must be considered together — a vented attic full of outdoor humidity is the condition that makes buried and attic ducts risky.
- **Never use building cavities as ducts.** Air handler support platforms, wall cavities, chases, shafts and mechanical closets are almost always leaky.
- **Design the return path deliberately.** Fully ducted returns per room, or properly sized transfer grilles and jumper ducts. In commercial ceiling plenums, verify crossover openings are correctly sized and that fire dampers operate.
- **Provide mechanical make-up air** sized against total exhaust, so the building can hold slight positive pressure. Outdoor air dehumidified at its point of entry is far easier to manage than moisture removed after it has mixed through the building.

5.3 SERVICE AND MAINTENANCE PROTOCOL

Every item below is either preventive against the failure modes documented in Parts 1 and 2, or diagnostic of them.

Every visit

- [ ] Replace filters; specify pleated media. Verify no bypass around the filter rack.
- [ ] Inspect and clear the condensate drain line; confirm steady discharge during operation.
- [ ] Inspect the drain pan for standing water, biofilm and slope. Confirm the trap is intact, correctly configured and not admitting air at velocity.
- [ ] Inspect the evaporator coil for biological growth and fouling. Photograph.
- [ ] Measure and log indoor temperature and RH, and record the thermostat setpoint and fan mode.
- [ ] Confirm fan mode is set to AUTO unless continuous operation is a deliberate, documented decision with a dehumidification strategy behind it.
- [ ] Check the blower-off delay; recommend disabling where maximum dehumidification is the priority.
- [ ] Verify supply registers are not aimed directly at interior surfaces.

Annually, or on any humidity or air-quality complaint

- [ ] Measure run-cycle length under load. Cycles materially shorter than 20 minutes at peak indicate oversizing or a control problem.
- [ ] Pressure-map the building: air handler off, air handler on, interior doors closed, exhaust equipment running.
- [ ] Measure whole-building pressure with respect to outdoors and confirm it is not negative.

- [ ] Measure duct leakage. Report as CFM25 and as a percentage of system airflow.
- [ ] Verify return transfer area against supply CFM for each closed-door room.
- [ ] Confirm dryer, bath, and kitchen exhaust all terminate outdoors — not into attic, crawlspace or soffit.
- [ ] Confirm range hood vents to exterior; recirculating hoods remove no cooking moisture.
- [ ] Inspect accessible duct runs, insulation, and buffer-zone piping for condensation and staining.
- [ ] Check for pink or yellow staining on any vinyl wall covering.
- [ ] Verify commercial make-up and outdoor air flows against total exhaust at the building boundary, not at the grille.

Occupant guidance to hand over

- Keep interior doors open when cooling unless the return path is fully engineered.
- Run bath and kitchen exhaust only while generating moisture; humidistat or timer control is preferable to a switch that gets left on.
- Avoid whole-house fans and extended open windows during humid periods — Florida outdoor RH approaches 100% on most nights regardless of daytime conditions, and materials will adsorb that moisture.
- Keep a digital temperature and RH sensor in the living space and check it. Daytime summer readings above 55% warrant a call.
- Manage exterior water: gutters and downspouts clear and directed away, grading sloped away, sprinklers not spraying walls.
- Repair any water leak promptly. Dry water-damaged materials within 24 hours where at all possible; consult a restoration professional for severe damage or damage standing more than 48 hours.
- Leave closet doors open or lights on — dark, unconditioned closets are a recurring mildew site, particularly on leather.
- Minimize live houseplants where humidity control is already marginal.

5.4 WHERE UV-C FITS

Coil and surface irradiation is the well-supported application: constant exposure at adequate proximity to hard surfaces such as coils and drain pans achieves very high inactivation rates, and the coil-cleanliness benefit shows up as measurable heat-transfer and fan-energy improvement. Airstream disinfection is far more variable and depends heavily on dose, geometry and lamp placement — a single lamp dropped into a system is not a design.

Specify by irradiance at the coil face, verify lamp wattage per square foot on the submittal, account for UV degradation of nearby polymers and filter media, and follow lockout/tagout with skin and eye protection during service. Sell it as a coil and pan hygiene tool that protects capacity — a defensible claim — rather than as an air purifier.

PART 6

THE DIAGNOSTIC TOOLKIT

These are the measurements that separate a diagnostic contractor from a parts-changer. Every one of them was developed or refined in Florida field research on the failure modes described in this brief.

6.1 BUILDING AIRTIGHTNESS

Envelope leakage is distributed across thousands of small cracks and cannot be measured directly. It is characterized indirectly as the airflow required to hold the building at a defined pressure — conventionally 50 Pa, reported as CFM50, or normalized to volume as ACH50:

> **ACH50 = CFM50 × 60 ÷ building volume**
>
> Worked example: 6,400 sq ft at 9 ft ceilings, CFM50 = 4,900. ACH50 = 4,900 × 60 ÷ (6,400 × 9) = 5.1 — inside the 4–8 target band.

Airtightness can also be inferred using the building's own exhaust equipment: shut down and mask make-up and outdoor air, measure total exhaust, read the resulting building pressure, and reference an airflow-versus-pressure chart. **Caution:** with a tight building or large exhaust flow this can drive pressures beyond −100 Pa and break glazing. Hold an exterior door open while shutting the fans down, then observe pressure as the door closes.

6.2 AIRFLOW MEASUREMENT — PICKING THE RIGHT TOOL

METHOD	APPLICATION AND LIMITS
Flow hood	Fastest when it works. Accurate to about ±5% in many applications, but can **overstate by as much as 80%** on registers that jet to one side of the hood. Generally limited to about 2,500 CFM and cannot capture most rooftop exhaust housings.
Pitot traverse	Accurate in skilled hands, but requires a straight run at least five duct diameters downstream of any elbow or restriction. Unusable in tightly turned sections. Measures what is in the duct at that point — not what reaches the building boundary.
Capture tent	Tent over the orifice with a calibrated blower in its side, adjusted until the tent sits at neutral pressure; blower flow then equals orifice flow. Works where a hood cannot, such as rooftop exhaust mushrooms.
Building as capture tent	Blower door in an exterior doorway used to restore normal operating pressure as each air-moving system is isolated in turn, yielding outdoor air, make-up air and exhaust flows by difference. Best in tighter buildings or with large equipment.
Calibrated fan on equipment	Fan mounted directly to the air handler cabinet with the return blocked; fan speed raised until supply plenum pressure returns to its normal operating value. Gives true air handler flow.
Tracer gas injection	Metered injection with upstream and downstream concentration sampling. Handles a wide range of flow rates and geometries — ducts, plenums, air handlers, exhaust, make-up and outdoor air. Often faster than a capture tent.

The governing rule: measurement location matters more than instrument choice. If the question is how much air leaves the building, measure at the building air boundary — a grille reading tells you nothing about what the duct loses between the grille and the roof. If the question is air handler flow, readings at supplies and returns will be wrong wherever duct leakage exists, and it usually does.

6.3 PRESSURE MAPPING

The single highest-value diagnostic for the failure modes in this brief. Pressure mapping establishes whether the building is positive or negative, whether combustion equipment will backdraft, which direction air is moving, where infiltrating air originates, which type of duct leakage dominates, whether return restrictions exist, and whether moisture problems are likely. It is performed as a pattern of readings across four states: air handler off, air handler on, interior doors closed, and exhaust equipment running. Hand-held digital manometers with auto-zero and time-averaging are adequate for one-time work; multi-channel logging over time reveals the swings that occur as equipment stages during real operation — the −3 to −17 Pa restaurant case being the illustration.

6.4 VENTILATION RATE BY TRACER GAS DECAY

Injecting a tracer gas, mixing it — injection into the return with 15–20 minutes of air handler mixing works well — and logging its decay gives the building's actual air exchange rate under the weather and operating conditions of that day:

$$ACH = (60 \div n) \times \ln(C_i \div C_f)$$

Where n is test duration in minutes, C_i is initial concentration and C_f is final concentration, both in ppm.

Two exceptions to interpretation: where restricted return air has some zones positive and others negative simultaneously, and where a leaky building sits near neutral pressure and natural infiltration adds to the mechanically induced rate.

PART 7

WHAT THE EVIDENCE DOES NOT SUPPORT

Knowing where the science stops is as commercially valuable as knowing where it holds. Every item below is a claim competitors make that we can decline to make — and explain why.

7.1 SPORE COUNTS AS A DECISION TOOL

Measured microbiologic factors in dust showed only limited, partly contradictory associations with health outcomes in the major reviews — including, for some agents, apparently protective associations. Reviewers concluded explicitly that current evidence does not support measuring specific indoor microbiologic factors to guide health-protective action. Air sampling has legitimate uses in scoping and in third-party clearance verification. It is not a diagnostic that tells a homeowner whether they have a problem, and it should never be sold as one.

7.2 SPRAYING INSTEAD OF REMOVING

S520-2024 strongly advises against applying chemicals, disinfectants or biocides to mold-contaminated areas without first physically and completely removing the growth and cleaning the surfaces — specifically because it conceals the underlying issue. NADCA's doctrine is source removal as the only acceptable cleaning method. And on lined ductwork the point is not merely best practice: **EPA has registered no antimicrobial product or biocide for that use at all.**

7.3 OZONE AND ANTIMICROBIAL DEVICES AS PRIMARY TOOLS

S520-2024 addresses ozone gas and other antimicrobial devices directly, advising they should not be relied upon as primary remediation tools. Treat them, at most, as adjuncts after source removal is complete.

7.4 ROUTINE DUCT CLEANING AS A HEALTH MEASURE

EPA does not recommend routine duct cleaning for all homes and states that evidence linking it to improved health in typical homes is inconclusive. Cleaning is indicated by condition — visible substantial growth, vermin, or heavy debris with particle release — not by calendar. EPA further warns that poor-quality cleaning can make indoor air worse, and that inadequate collection equipment can release more than it removes.

This is not a threat to the business; it is the case for the business. If cleaning is indicated by measured condition and documented with imagery, the recommendation is defensible. If it is sold on a schedule to every household, EPA's own consumer guidance is a ready-made objection in the customer's hand.

7.5 HOUSEHOLD CHEMISTRY IN DUCTWORK

Bleach and vinegar are widely recommended online for duct and vent cleaning and are inappropriate for that use — they add moisture to the system and do not accomplish source removal. Dilute bleach solution remains a reasonable homeowner measure for routine bathroom tile and grout cleaning, which is a different problem on a non-porous, drying surface.

7.6 "TOXIC BLACK MOLD" FRAMING

Stachybotrys chartarum requires cellulose-rich material with prolonged water exposure, which makes it comparatively unlikely to establish in ductwork itself. More importantly, the remediation response does not change by species: any indoor growth at sufficient concentration affects air quality, and the corrective action is source removal plus moisture correction regardless of colour or genus. Species identification rarely changes the scope of work and should not be used to escalate a sale.

THE POSITION

Action Air's competitive claim is not that we detect more than others. It is that we **measure the things that determine the outcome** — pressure, airflow, leakage, run time, humidity — and that we decline to charge for the things that don't. Every declined claim above is a reason for a skeptical customer to trust the claims we do make.

APPENDIX A

THRESHOLD REFERENCE CARD

VALUE	THRESHOLD
Indoor RH — general target	Below 60%; ideally 30–50%
Indoor RH — summer daytime action level	Above 55% routinely = investigate
Surface water activity supporting growth	≥ 70% equivalent RH
Extended RH indicating dehumidification need	70–75%+ sustained
Evaporator coil operating temperature	~40–50 °F
Florida summer outdoor dewpoint	Commonly > 80 °F
Time to reach full latent capacity from cycle start	~3 minutes
Target peak-load run cycle	20–30 minutes
Building pressure vs. outdoors	Slightly positive, ~2–3 Pa
Pressure across closed interior doors	≤ 2 Pa
Shell airtightness band (commercial)	4–8 ACH50
Total duct leakage target	≤ 6%
Return transfer area — free opening	50 sq in per 100 CFM supply
Return transfer area — grilled opening	~70 sq in per 100 CFM supply
UV-C irradiance at coil face	50–100 µW/cm² (~7.5 lamp W/sq ft)
Filter replacement interval	1–3 months
Wet material drying window	Within 24 hours; professional help beyond 48
EPA area tiers	<10 sq ft / 10–100 sq ft / >100 sq ft
Professional remediation triggers	>100 sq ft, HVAC involvement, or vulnerable occupants
Vacant home strategy A	Dehumidifier on timer, 3–4 hrs/day
Vacant home strategy B	74 °F from 3–6 AM; 85 °F balance of day

ONE-LINE VERSION FOR TECHNICIANS

If indoor RH runs above 55% on a summer afternoon with the system operating, something is wrong — and it is almost always sizing, duct leakage, charge, airflow across the coil, or building pressure. Measure before you quote.

APPENDIX B

SOURCES

Federal and public health guidance

US EPA — A Brief Guide to Mold, Moisture and Your Home. epa.gov/mold/brief-guide-mold-moisture-and-your-home

US EPA — Mold Course, Chapter 2 (moisture, HVAC, duct liner, biocide registration) and Chapter 5 (remediation, HVAC containment protocol, PPE). epa.gov/mold/mold-course-chapter-2 · epa.gov/mold/mold-course-chapter-5

US EPA — Mold Remediation in Schools and Commercial Buildings, Chapter 3. epa.gov/mold/mold-remediation-schools-and-commercial-buildings-guide-chapter-3

US EPA — Should You Have the Air Ducts in Your Home Cleaned? epa.gov/indoor-air-quality-iaq/should-you-have-air-ducts-your-home-cleaned

CDC / NIOSH — Mold: Health Problems. cdc.gov/niosh/mold/health-problems/index.html

Industry standards

ANSI/IICRC S520-2024 — Standard for Professional Mold Remediation, 4th edition. Superseding the 2015 third edition; source-removal emphasis, biocide guidance, Section 9.1.7 on ozone and antimicrobial devices.

NADCA — ACR, The NADCA Standard for Assessment, Cleaning & Restoration of HVAC Systems. 2021 edition free at acrstandard.nadca.com; 2025 edition via NADCA store. nadca.com/industry-professionals/standards-and-publications

NADCA — White Paper on Ultraviolet Lighting Applications in HVAC Systems. nadca.com (2021)

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SMACNA — HVAC Air Duct Leakage Test Manual.

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Fairey, P., Chandra, S. & Moyer, N. — Mold Growth. Florida Solar Energy Center, UCF. *Primary source for growth requirements, water activity, fan mode and setpoint RH data, pressurization, return air sizing, occupant guidance.* energyresearch.ucf.edu

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US DOE / Building America — Moisture and Ventilation Solutions in Hot, Humid Climates: Florida Manufactured Housing. *101-house duct*

leakage dataset; mastic vs. tape. energy.gov

Trent, W. & Trent, C. — Indoor Air Quality and the Condensate Trap. Ninth Symposium on Improving Building Systems in Hot and Humid Climates, 1994.

Building Science Corporation — BSD-012: Moisture Control for New Residential Buildings. buildingscience.com

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Institute of Medicine — Damp Indoor Spaces and Health, 2004.

WHO — Guidelines for Indoor Air Quality: Dampness and Mould, 2009.

Mendell, M.J., Mirer, A.G., Cheung, K., Tong, M. & Douwes, J. — Respiratory and Allergic Health Effects of Dampness, Mold, and Dampness-Related Agents: A Review of the Epidemiologic Evidence. Environmental Health Perspectives, 2011. DOI 10.1289/ehp.1002410

Fisk, W.J., Lei-Gomez, Q. & Mendell, M.J. — Meta-analyses of the associations of respiratory health effects with dampness and mold in homes, 2007.

Mudarri, D. & Fisk, W.J. — Public health and economic impact of dampness and mold, 2007.

Quansah, R. et al. — Residential Dampness and Molds and the Risk of Developing Asthma: A Systematic Review and Meta-Analysis. PLOS ONE, 2012.

Lawrence Berkeley National Laboratory — IAQ Science: Dampness and Mold. iaqscience.lbl.gov/dampness-and-mold

Coil fouling and UVGI

Energy and Buildings — Effectiveness of an ultraviolet germicidal irradiation system in enhancing cooling coil energy performance in a hot and humid climate. *Source of the 10% conductance / 13% pressure drop / 9% fan energy field results.*

AMCA InMotion — UV-C for HVAC Air and Surface Disinfection. *Coil irradiance specification guidance.*

> **COMPILATION NOTE**
>
> Prepared as an internal technical and training reference for Action Air Conditioning & Refrigeration and Real Duct Cleaning LLC. Figures are reported as published by the cited sources; field values should be verified against current editions of the standards, which are periodically revised. Nothing here constitutes medical advice, and health questions raised by customers should be referred to a physician.