NADCA White Paper:
Restoring Energy Efficiency Through HVAC Air Distribution System Cleaning

Presented by
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White Paper Subcommittee

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Purpose of the White Paper

- ✓ Energy consumption is critical aspect for HVAC systems
- ✓ HVAC engineering, construction & maintenance play major roles in optimizing energy usage
- ✓ Provides quantifiable methods for measuring energy savings pre- and post-cleaning

Disclaimer

- Although the following information reflects current methods for energy monitoring in the cleaning of HVAC systems, readers should recognize that new developments regularly occur and should familiarize themselves with the most current information when determining the appropriate steps to take.
- NADCA recognizes that differences in opinion exist as to how to measure and interpret energy efficiency in HVAC systems. We have endeavored in this paper to find consensus among a broad spectrum of representatives in the HVAC cleaning industry, test and balance industry, and energy efficiency field.
- This document was written in the United States of America and is intended primarily for use in that country. This material may also prove useful for industry professionals and others operating outside the USA. All users of this document are encouraged to refer to applicable federal, state/provincial, and local authorities having jurisdiction over the subjects addressed within this document.

An Example of Measuring Cleaning Performance

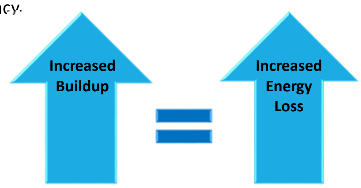
Room	Volume in CFM	Before/After	Duct Type
3026	56	After	Exh
3026	16	Before	Exh
3019	95	After	Exh
3019	58	Before	Exh
3013	99	After	Exh
3013	37	Before	Exh
3008	82	After	Exh
3008	45	Before	Exh
3007	91	After	Exh
3007	33	Before	Exh
3003	83	After	Exh
3003	48	Before	Exh

Condenser Coil Cleaning

- Typically not part of cleaning process per ACR
- Can have significant positive impact on energy efficiency
- Methods for cleaning similar to those of cleaning evaporator coils
- Consider as an add-on option to restore greater energy efficiency

How Cleaning Restores Energy Efficiency

- Through normal HVAC usage, particulate slowly collects on surfaces of components. This results in gradual loss of energy efficiency.

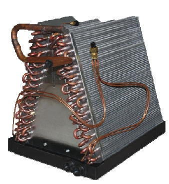


Cleaned Components - Restore Energy

Evaporator Coil

Particulate buildup over time has insulating effect on surface of coil, leading to longer cooling times & greater energy consumption

Buildup between fins of coil increasingly restricts airflow over time



❖*Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Heating Coil

Restriction in passages reduces airflow & diminishes effectiveness

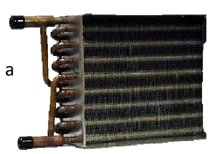
Frequent cause of restriction is accumulation of dust, dirt & other fouling agents

- *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Reheat Coil

Fins can be narrow and can act almost as a filter, filling with particulate over time



- *Periodic inspection & cleaning of coil are needed*
- *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Turning Vanes

Particulate collection can narrow spaces between vanes

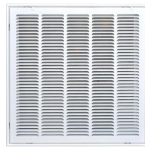
Large debris blowing through ducts can get caught on vanes and create significant blockage

- *Remove debris during cleaning process*

Cleaned Components - Restore Energy

Supply Air Outlet (Register)

Dirt & debris build up on blades reduces airflow



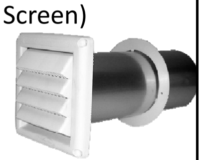
Return Air Inlet (Register)

Dirt & debris build up restricts air movement and can cause it to become completely clogged

❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Fresh Air Intake Screen (Outside Air Screen)



Screens become plugged by debris getting caught on screen or mesh

Debris inhibits proper fresh airflow into building which leads to improper pressure within the building

❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Fan (Blower)

Particulate buildup on blades reduces capacity of blades to move air causing blower motor to run longer while pushing less air per rotation.

❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Damper

Excessively dirty dampers restrict airflow.

Heavy particulate buildup may restrict movement of blades resulting in restricted airflow and possible increased back pressure on the system & compressor.

❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Sound Attenuator

When dirty or impacted, amount of air delivered through duct system is reduced.

Restriction can affect airflow, temperature & comfort level.

❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Duct Liner

Separated insulation will reduce airflow

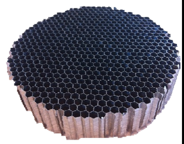
Loose insulation can blow downstream and land on other component surfaces (i.e.. coils, supply air outlets, volume dampers)

❖ *Inspect, remove & replace in accordance with ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Air Straightener

Can become clogged with dust and debris and serve as impaction point for failing duct insulation and other large debris.



Clogging restricts airflow and energy efficiency.

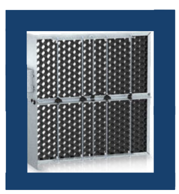
❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Air Flow Measuring Station (AFMS)

Clogged pitot tubes and air lines can cause calibration issues

Flawed airflow calculations can cause improper control of ventilation (outdoor) air



Cleaned Components - Restore Energy

Velocity Sensors/Controllers

Clogged sensors can cause problems ranging from comfort complaints to increased energy consumption.

Cleaned Components - Restore Energy

Mist Eliminators

Particulate buildup causes eliminator to lose ability to properly remove moisture & reduces airflow through the system

Causes an increase in back pressure, forcing the system to use more energy

- ❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

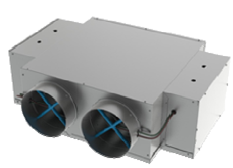
Humidifier

Particulate buildup over time creates greater resistance to airflow

Cleaned Components - Restore Energy

Mixing Box

Internal components can accumulate dust & debris, restricting airflow



- ❖ *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

VAV Box

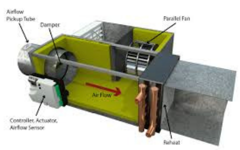
Screens and other parts in the air stream can collect dust & dirt over time, restricting airflow & efficiency

- *Clean according to ACR, The NADCA Standard*

Cleaned Components - Restore Energy

Fan-Powered Box

Dirt buildup on fan blades and housing interior can reduce airflow



- *Clean according to ACR, The NADCA Standard*

Measuring Air Distribution System Performance, Before and After Cleaning

Accurately measuring energy consumption and air dynamics in HVAC systems is complex and requires extensive training.

Methods described offer simplified approach to approximating HVAC performance before and after cleaning.

They are not intended to replace, and are not comparable to, more thorough methods used by testing and balancing professionals, HVAC engineers, etc.

Measuring Air Distribution System Performance, Before and After Cleaning

Proper cleaning of a dirty HVAC system will result in some degree of improved airflow & improved heat transfer in cleaned coils.

Determining percentage of improvement permits cleaning contractor and system owner to establish cost/benefit ratio for periodic cleaning.

Measuring Air Distribution System Performance, Before and After Cleaning

Determining system performance requires cubic feet per minute (CFM) output and temperature change before and after the coils.

From this we can calculate the output of the system in BTUs or British Thermal Units.

For systems with fresh air intakes, an additional measurement of humidity is required before and after the coils.

Measuring Air Distribution System Performance, Before and After Cleaning

Filters, dirty or clean, restrict airflow. To ensure that a change in filters does not skew pre- and post-cleaning measurements, filters must be in the same condition for both readings when measuring CFM before and after cleaning.

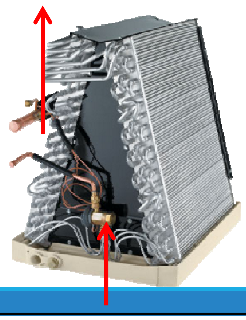
That is, if the filters are new, used, or removed for the "before" CFM reading, they must be the same for the "after" reading.

Where Measurements are Taken

Measure:

Temperature of air leaving coil

Relative Humidity of air leaving coil



Measure:

Temperature of air entering coil

Relative Humidity of air entering coil

Where Measurements are Taken

Air discharge side of coil

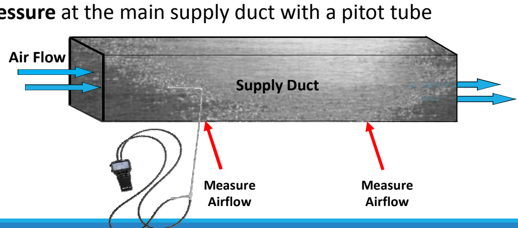
Air entering coil

Where Measurements are Taken

Traverse Measurement

Measure:

Air Pressure at the main supply duct with a pitot tube



PITOT TUBE

Where Measurements are Taken

Measure:

Air velocity or air volume, if needed, is measured at a return register.

Formulas for Measuring BTU Output

We have two different formulas for measuring HVAC performance.

These formulas provide a way to calculate BTUs consumed by the HVAC system before and after cleaning.

For example, if BTUs are 10,000 before cleaning and 15,000 after, we have created a 50% improvement in capacity, which equates to greater energy efficiency.

Formula 1

BTUs/hour = CFM x ΔT x 1.08

- For systems with no fresh air intake, primarily residential systems.
- *Temperature* (T) is the dry-bulb temperature of the air measured entering and leaving the evaporator coil (Δ*T)*.
- This formula provides the sensible heat load across the evaporator coil.

Formula 2

BTUs/hour = CFM x Δh x 4.5

- For systems with fresh air intake, includes most commercial systems
- Formula provides total heat load (sensible + latent) across the evaporator coil
- "h" stands for enthalpy. Enthalpy is the total quantity of heat energy contained in a substance, also called total heat. Measurement is in BTU/lb. of dry air.
- *In order to determine h (enthalpy), both the dry-bulb temperature and relative humidity (or, as an alternative, the wet bulb temperature)* of the air entering and leaving the evaporator coil is required.

In-Duct Psychrometer

Formula to Measure Energy Savings

Formula determines % of reduction in energy cost to consumer:

BTU/hr output after cleaning *MINUS* BTU/hr output before cleaning
***DIVIDED BY* BTU/hr output after cleaning**

Output **after** cleaning → 3000; Output **before** cleaning → 2000

Example: 3000 BTUs/hr – 2000 BTUs/hr = 1000 BTUs/hr;

1000/3000 = .33 or **33%** ← **Reduction in HVAC energy cost.**

Note: Formula determines energy savings from HVAC use only, not energy savings for client's entire power bill.

Equipment Required: Formula 1

- ✓ Electronic thermometer: measures temperature
- ✓ Manometer: measures air pressure
- ✓ Pitot tubes: attach to manometer & inserted into duct or air stream to measure air pressure.
- ✓ Rotating vane anemometer: measures air velocity in FPM.

Equipment Required: Formula 2

- ✓ Electronic thermometer and hygrometer: A digital instrument that measures temperature and relative humidity
- ✓ Manometer: measures air pressure
- ✓ Pitot tubes: attach to manometer & inserted into duct or air stream to measure air pressure.
- ✓ Rotating vane anemometer: measures air velocity in FPM.

Flow Hood

Taking Measurements

NADCA White Paper provides step-by-step instructions for taking measurements:

- ✓ Evaporator Coil
- ✓ Calculating Temperature Readings (Delta T)
- ✓ Measuring CFM – Return Inlet/Supply Outlet Airflow
- ✓ Main Supply Duct Airflow

Image of duct traverse reading courtesy of www.achrnews.com

Formula 1 Calculations

	NADCA ENERGY EFFICIENCY: FORMULA 1		
	Before Cleaning	After Cleaning	
Temp. Before Coil	72	72	
Temp. After Coil	50	45	
Δt	22	27	
CFM	200	225	
FORMULA 1 BEFORE: CFM x Δt x 1.08	4752		
FORMULA 1 AFTER: CFM x Δt x 1.08	6561		
Energy Improvement	38%		
Energy Savings	28%		

Formula 2 Calculations

	NADCA ENERGY EFFICIENCY FORMULA 2			
Psychrometric Chart Online: http://www.daytonashrae.org/psychrometrics_imp.html#start				
	Before Cleaning	After Cleaning		
Temp. Before Coil	76	73		
Temp. After Coil	68	54		
Δt	8	19		
CFM	1200	1500		
Relative Humid. Before Coil	65	55		
Relative Humid. After Coil	75	99		
Enthalpy Before Coil (Per Psych. Chart)	31.94	27.94		
Enthalpy After Coil (Per Psych. Chart)	28.31	22.5		
Δh	3.63	5.44		
BEFORE FORMULA 2: CFM x Δh x 4.5	19602			
AFTER FORMULA 2: CFM x Δh x 4.5	36720			
Energy Improvement	87%			
Energy Savings	47%			

Calculation Spreadsheets

Excel spreadsheets containing Formula 1 and Formula 2 calculations available for download with the NADCA White Paper.

Simply enter the measurements and the calculations will be provided.

Free download available at www.nadca.com

Identifying Energy Waste During HVAC Inspection & Cleaning Process

Common Problems Identified

- Duct and system leakage
- Closed, improperly set, or stuck dampers
- Filtration issues
- Excess flex ductwork
- Damaged ductwork
- Failed duct liner
- Clogged or nonfunctioning exhaust systems

Identifying Energy Waste During HVAC Inspection & Cleaning Process

Common Problems Identified

- Deteriorating coils
- Inefficient energy recovery systems
- Missing or broken turning vanes, dampers and other duct components
- Poorly functioning or non-functioning HVAC equipment
- Poor system design
- Broken or worn belts and sheaves (pulleys)
- Unbalanced Airflow

HVAC Cleaning Energy Audit Checklist

Below is a list of common problems found in HVAC air distribution systems. It is important that the cleaning contractor note and report any such items to the system owner or the owner's representative. These items should only be remedied by those trained and, if necessary, licensed to do so.

- ❑ **Duct and system leakage**
- ❑ **Closed, improperly set, or stuck dampers**
- ❑ **Filtration issues**
- ❑ **Excess flex ductwork**
- ❑ **Damaged ductwork**
- ❑ **Failed duct liner**
- ❑ **Clogged or nonfunctioning exhaust systems that fail to remove air per building design (bathroom, hallway, operating room, etc.)**
- ❑ **Deteriorating coils**
- ❑ **Inefficient energy recovery systems**
- ❑ **Missing or broken turning vanes, dampers and other duct components**
- ❑ **Poorly functioning or non-functioning HVAC equipment**
- ❑ **Poor system design**
- ❑ **Broken or worn belts and sheaves (pulleys)**
- ❑ **Unbalanced Airflow**

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