ACM RE-2005

# Appendix RE – Field Verification and Diagnostic Testing of Forced Air System Fan Flow and Air Handler Fan Watt Draw

## *RE1. Purpose and Scope*

ACM RE-2005 contains procedures for verifying adequate airflow in split system and packaged air conditioning systems serving low-rise residential buildings. The procedure is also used to verify reduced fan watts achieved through improved air distribution design, including more efficient motors and air distribution systems with fewer obstructions. The refrigerant charge test described in ACM RE requires as a prerequisite that adequate airflow be verified. In addition, the reference method algorithms offer a credit for low fan power which can be obtained through diagnostic measurements. Table RE-1 summarizes the diagnostic measurement procedures in ACM RE-2005 and shows their relationship to the equipment efficiency algorithms in ACM Chapter 4.

*Table RE-1 – Summary of Diagnostic Measurements*

| Input to the Algorithms | Variables and Equation Reference | Description | Standard Design Value | Proposed Design | |
|---|---|---|---|---|---|
| | | | | Default Value | Procedure |
| Fan Power Ratio | FanW/Btu (Eq. R4-45) | The ratio of fan power in Watts to the cooling capacity in Btu/h. | 0.051 W/Btu. | 0.051 W/Btu. | Section RE4.4.3 |
| Fan Flow over Evaporator | $F_{air}$ (Eq. R4.42 and R4.43) | The term $F_{air}$ depends on the measured airflow over the evaporator coil. A value of 0.925 is used as a default, but a value of 1.000 can be used if measured airflow exceeds 350 cfm per ton | $F_{air}$ = 1.000 when refrigerant charge testing is required by Package D. | $F_{air}$ = 0.925 | Section RE4.4.1 |
| Refrigerant Charge Prerequisite | n. a. | An airflow of at least 300 cfm/ton must be obtained before a valid refrigerant charge test may be performed | n. a. | n. a. | Section RE4.4.1 |

## *RE2. Instrumentation Specifications*

The instrumentation for the diagnostic measurements shall conform to the following specifications:

### RE2.1 Pressure Measurements

All pressure measurements shall be measured with measurement systems (i.e., sensor plus data acquisition system) having an accuracy of ± 0.2 Pa. All pressure measurements within the duct system shall be made with static pressure probes.

### RE2.2 Fan Flow Measurements

All measurements of distribution fan flows shall be made with measurement systems (i.e., sensor plus data acquisition system) having an accuracy of ± 7% reading or ± 5 cfm whichever is greater.

### RE2.3 Watt Measurements

All measurements of air handler watt draws shall be made with true power measurement systems (i.e., sensor plus data acquisition system) having an accuracy of ± 2% reading or ± 10 watts whichever is greater.

## *RE3. Apparatus*

### RE3.1 System Fan Flows

HVAC system fan flow shall be measured using one of the following methods.

#### *RE3.1.1 Plenum Pressure Matching Measurement*

The apparatus for measuring the system fan flow shall consist of a duct pressurization and flow measurement device (subsequently referred to as a fan flowmeter) meeting the specifications in RE2.2, a static pressure transducer meeting the specifications in Section RE2.1, and an air barrier between the return duct system and the air handler inlet. The measuring device shall be attached at the air handler blower compartment door. All registers shall be in their normal operating condition. The static pressure probe shall be fixed to the supply plenum so that it is not moved during this test.

#### *RE3.1.2 Flow Capture Hood Measurement*

A flow capture hood meeting the specifications in Section RE2.2 may be used to verify the fan flow at the return register(s). All registers shall be in their normal operating position. Measurement(s) shall be taken at the return grill(s).

#### *RE3.1.3 Flow Grid Measurement*

The apparatus for measuring the system fan flow shall consist of a flow measurement device (subsequently referred to as a fan flow grid) meeting the specifications in RE2.2 and a static pressure transducer meeting the specifications in Section RE2.1. The measuring device shall be attached at a point where all the fan airflow shall flow through the flow grid. All registers shall be in their normal operating condition. The static pressure probe shall be fixed to the supply plenum so that it is not moved during this test.

### RE3.2 Air Handler Watts

The air handler watt draw shall be measured using one of the following methods.

#### *RE3.2.1 Portable Watt Meter Measurement*

The apparatus for measuring the air handler watt draw shall consist of a watt meter meeting the specifications in RE3.1.3. The measuring device shall be attached to measure the air handler fan watt draw. All registers shall be in their normal operating condition.

#### *RE3.2.2 Utility Revenue Meter Measurement*

The apparatus for measuring the air handler watt draw shall consist of the utility revenue meter meeting the specifications in RE3.1.3 and a stopwatch measuring in seconds. All registers shall be in their normal operating condition.

## *RE4. Procedure*

To determine and verify airflow credit a diagnostic fan flow measurement shall demonstrate air flow greater than 350 cfm per ton and installation of the duct system must be designed to meet the criteria in RE4.2. For multi-zone systems the measured airflow must exceed 350 cfm per ton in each and every operating mode of the system. This must be accomplished without bypasses from the supply ductwork to the return ductwork. Note: All airflows are for the fan set at the speed used for air conditioning.

To determine and verify airflow and fan watt draw credit, in addition to verifying air flow, the air handler fan watt draw measurement shall show fan watts less than that claimed in ACM calculations and shown in CF-1R.

## RE4.1 Diagnostic Fan Flow

The system passes the fan flow test if the fan flow measured using one of the following methods is greater than 350 cfm per ton.

### *RE4.1.1 Diagnostic Fan Flow Using Flow Capture Hood*

The fan flow measurement shall be performed using the following procedures; all registers shall be fully open, and the air filter shall be installed. Turn on the system fan at the maximum speed used in the installation (usually the cooling speed when air conditioning is present) and measure the fan flow at the return grille(s) with a calibrated flow capture hood to determine the total system return fan flow. The system fan flow (Qah, cfm) shall be the sum of the measured return flows.

### *RE4.1.2 Diagnostic Fan Flow Using Plenum Pressure Matching*

The fan flow measurement shall be performed using the following procedures:

1. If the fan flowmeter is to be connected to the air handler outside the conditioned space, then the door or access panel between the conditioned space and the air handler location shall be opened.
2. With the system fan on at the maximum speed used in the installation (usually the cooling speed when air conditioning is present), measure the pressure difference (in pascal) between the supply plenum and the conditioned space (Psp). Psp is the target pressure to be maintained during the fan flow tests. If there is no access to the supply plenum, then place the pressure probe in the nearest supply duct. Adjust the probe to achieve the highest pressure and then firmly attach the probe (e.g., with duct tape) to ensure that it does not move during the fan flow test.3. Block the return duct from the plenum upstream of the air handler fan and the fan flowmeter. Filters are often located in an ideal location for this blockage.
3. Attach the fan flowmeter device to the duct system at the air handler. For many air handlers, there will be a removable section that allows access to the fan that is suitable for this purpose.
4. Turn on the system fan and the fan flow meter, adjust the fan flowmeter until the pressure between supply plenum and conditioned space matches Psp.
5. Record the flow through the flowmeter (Qah, cfm) - this is the diagnostic fan flow. In some systems, typical system fan and fan flowmeter combinations may not be able to produce enough flow to reach Psp. In this case record the maximum flow (Qmax, cfm) and pressure (Pmax) between the supply plenum and the conditioned space. The following equation shall be used to correct measured system flow and pressure (Qmax and Pmax) to operating condition at operating pressure (Psp).

Equation RE-1 Air Handler Flow Qah = Qmax x (Psp/Pmax) ^.5

### *RE4.1.3 Diagnostic Fan Flow Using Flow Grid Measurement*

The fan flow measurement shall be performed using the following procedures:

1. With the system fan on at the maximum speed used in the installation (usually the cooling speed when air conditioning is present measure the pressure difference (in pascal) between the supply plenum and the conditioned space (Psp). If there is no access to the supply plenum, then place the pressure probe in the nearest supply duct. Adjust the probe to achieve the highest pressure and then firmly attach the probe (e.g., with duct tape) to ensure that it does not move during the fan flow test.
2. The flow grid shall be attached at a point where all the fan air flows through the flow grid.
3. Re-measure the system operating pressure with the flow grid in place.
4. Measure the air flow through the flow grid (Qgrid) and the test pressure (Ptest).
5. The following equation for air handler flow shall be used to correct flow through the flow grid and pressure (Qgrid and Ptest) to operating condition at operating pressure (Psp).

Equation RE-2 Qah = Qmax x (Psp/Ptest) ^.5

## RE4.2 Duct Design

The duct system installation shall be verified to be consistent with the design meeting the following requirements. The duct system shall be designed to meet the airflow rate with the available external static pressure from the air handler at that airflow. The duct design shall have calculations showing the duct system will operate at equal to or greater than 0.0292 cfm/Btu rated capacity at ARI test condtions (350 cfm/12000 Btu) in cooling speed or, if heating only, equal to or greater than 16.8 cfm per 1000 Btu/hr furnace output. The design shall be based on the available external static pressure from the air handler, the pressure drop of external devices, the equivalent length of the runs, as well as the size, type and configuration of the ducts. The duct layout shall be included on the plans and the duct design shall be reported on the CF-6R and posted on-site.

## RE4.3 Diagnostic Air Handler Watt Draw

The system passes the Watt Draw test if the air handler watt draw is less than or equal to the value claimed in compliance calculations and reported by the ACM on the CF-1R.

For multi-zone systems the measured air handler watt draw must be less than or equal to the value claimed in compliance calculations and reported by the ACEM on the CF-1R. This must be accomplished without bypasses from the supply ductwork to the return ductwork. Note: All airflows are for the fan set at the speed used for air conditioning.

The diagnostic air handler watt draw shall be measured using one of the following methods:

### *RE4.3.1 Diagnostic Air Handler Watt Draw Using Portable Watt Meter*

The air handler watt draw measurement shall be performed using the following procedures; all registers shall be fully open, and the air filter shall be installed. Turn on the system fan at the maximum speed used in the installation (usually the cooling speed when air conditioning is present) and measure the fan watt draw (Wfan).

### *RE4.3.2 Diagnostic Air Handler Watt Draw Using Utility Revenue Meter*

The air handler watt draw measurement shall be performed using the following procedures; all registers shall be fully open, and the air filter shall be installed. Turn on the system fan at the maximum speed used in the installation (usually the cooling speed when air conditioning is present) and turn off every circuit breaker except the one exclusively serving the air handler. Record the Kh factor on the revenue meter, count the number of full revolutions of the meter wheel over a period exceeding 90 seconds. Record the number of revolutions (Nrev) and time period (trev, seconds). Compute the air handler watt draw (Wfan) using the following formula:

Equation RE-3 Air Handler Fan Watt Draw $Wfan = ( Kh \times Nrev \times 3600) / trev$

Return all circuit breakers to their original positions.