

**ENERGY STAR<sup>®</sup> Testing Facility Guidance Manual:**  
**Building a Testing Facility and Performing the Solid State Test  
Method for ENERGY STAR Qualified Ceiling Fans**



**Version 1.0  
September 20, 2002**

**Prepared by:  
The US Environmental Protection Agency**

**Contributing Laboratories:  
Hunter Fan Company  
Intertek Testing Services, ETL SEMKO  
Underwriters Laboratory, Taiwan Branch**

# ENERGY STAR® Testing Facility Guidance Manual: Building a Testing Facility and Performing the Solid State Test Method for ENERGY STAR Qualified Ceiling Fans

I.	Table of Contents .....	1
II.	Chapter 1: Introduction .....	3
III.	Chapter 2: List of Equipment and Vendors .....	5
IV.	Chapter 3: Air Delivery Room Construction and Preparation .....	7
V.	Chapter 4: Equipment Set-Up and Test Procedure .....	13
VI.	Chapter 5: Calibration Approval and Reporting Testing Results .....	17
VII.	Chapter 6: Definitions and Acronyms .....	20

## Appendices

### Appendix A

ENERGY STAR Program Requirements for Residential Ceiling Fans: Eligibility Criteria

### Appendix B

ENERGY STAR Qualified Product Information Form

### Appendix C

Laboratory Reporting Form(s)

### Appendix D

Engineering Blueprints for Air Delivery Room

## List of Figures

Figure 3.1 – Rail Track in Ceiling

Figure 3.2 – Rail Measurements and Details

Figure 3.3 – Test Cylinder and Rail Track Support

Figure 3.4 – Arm Rotator with Sensor Wires Covered

Figure 3.5 – Sensors Mounted in Testing Position

Figure 3.6 – Sensors and Sensor Rotating Arm

Figure 3.7 – Testing Cylinder, Actuator, and Sensor Rotating Arm

Figure 3.8 – Air Delivery Room Set-Up with 60” Cylinder

Figure 3.9 – Testing Cylinder and Chamber

Figure 4.1 – Temperature and Humidity Sensors in Testing Room

Figure 4.2 – Tachometer Set-Up

Figure 4.3 – Testing Room and All 4-Axis

Figure 4.4 – Ceiling Fan Testing Set-Up

**This test manual will be updated and augmented as necessary in response to changes in testing requirements and specifications under the ENERGY STAR Program Requirements for Residential Ceiling Fans.**

**For questions related to ENERGY STAR contact:**

**Andrew Fanara, EPA  
Program Manager  
ENERGY STAR for Residential Ceiling  
Fans  
1200 Pennsylvania Avenue  
Washington, DC 20460  
Phone: (202) 564-9019  
E-mail: [fanara.andrew@epa.gov](mailto:fanara.andrew@epa.gov)**

**Rebecca Miller, ICF Consulting  
1850 K Street NW, Suite 1000  
Washington, DC 20006  
Phone: (202) 862-1266  
E-mail: [rmiller@icfconsulting.com](mailto:rmiller@icfconsulting.com)**

**The laboratories listed below contributed to the development of this testing manual. For technical questions related to this document contact:**

**Vin Mehta  
Engineering Manager  
Hunter Fan Company  
2500 Frisco Avenue  
Memphis, TN 38114  
(901) 248-2212  
E-mail: [vmehta@hunterfanco.com](mailto:vmehta@hunterfanco.com)**

**Mike Chang  
Underwriters Laboratory (UL)  
Taiwan Branch  
4<sup>th</sup> Floor, 260 Da-Yeh Rd., Peitou  
Taipei City, Taiwan 112  
886-2-2896-7790 ext. 279  
E-mail: [mike.chang@tw.ul.com](mailto:mike.chang@tw.ul.com)**

**Jason Prentice  
Engineer  
Intertek Testing Services (ITS)  
ETL Semko  
3933 US Route 11  
Cortland, NY 13045  
(607) 753-6711  
E-mail: [jprentice@etlsemko.com](mailto:jprentice@etlsemko.com)**

**EPA would like to thank all those interested parties who contributed comments during the development of this document, especially Natural Resources Canada.**

**Additional comments on this document should be directed to Rebecca Miller, ICF Consulting, at [rmiller@icfconsulting.com](mailto:rmiller@icfconsulting.com).**

# CHAPTER 1

## Introduction

### 1.1 Background

ENERGY STAR is a self-certifying, voluntary program that manufacturers can join to qualify and label their energy-efficient products. Where possible, ENERGY STAR adopts existing testing procedures when developing product specifications and testing criteria. However, there was no standardized test method available to the ceiling fan industry at the time of specification development for this product.

In 2001, EPA partnered with Hunter Fan Company to develop the Solid State Test Method. This test method is designed to increase efficiency and improve accuracy. It provides an accurate representation of the air circulation created by the fan in the room. The method reduces the testing and validation time to a fraction of the time period required by other industry testing standards.

The Solid State Test Method allows for the measurement of total cubic feet per minute (CFM) and CFM/watt readings for multiple fan speeds. These results must meet the minimum requirements provided in the ENERGY STAR specification (Attachment A). As of January 2001, all fans must be tested in accordance with the Solid State Test Method in order to qualify as ENERGY STAR.

The Solid State Test Method was provided by Hunter Fan Company as non-proprietary and is subject to improvements as technologies change and standard operating procedures are re-evaluated.

### 1.2 Purpose

The purpose of this guidance manual is to provide ENERGY STAR partners and other interested parties, such as third party laboratories, the necessary information needed to build a ceiling fan testing chamber, or air delivery room, and perform adequate product testing for ENERGY STAR qualification. It is important to note that this manual provides the minimum requirements for building the test facility. Engineering designs may vary outside of these minimum requirements. The testing criteria and procedure, however, shall be followed closely in order to ensure consistent results across the board.

This following information is provided in this manual:

- List of equipment and reference vendor contacts
- Air delivery room construction and set-up
- Equipment set-up and CFM test procedure
- Approval process, programmatic requirements, and required forms
- ENERGY STAR specifications
- Blueprints for air-delivery room

### 1.3 Applicability

Any ceiling fan manufacturer, third-party testing facility, or other interested party may build a ceiling fan test chamber. All testing facilities intending to test residential ceiling fans under ENERGY STAR requirements must follow the facility blueprints and additional building instructions as well as the test procedures provided in this manual. **Please note that this is not an EPA certification and individuals shall not attempt to identify themselves as an EPA certified laboratory.**

Third-party testing facilities and laboratories should already be accredited or recognized by an independent laboratory certification organization (e.g., UL, Intertek Testing Services) to conduct testing and review test results. For those facilities that are not already accredited or recognized, a facility inspection will be required prior to approval of the facility. Representatives from EPA and an existing ceiling fan testing laboratory, approved to test for ENERGY STAR qualification, will conduct this inspection to ensure the proper procedures and reporting requirements are in place.

## CHAPTER 2

### List of Equipment and Vendors

The table below provides a list of the testing equipment needed to perform the Solid State Test Method. With the exception of the sensors and sensor software, any precision control equipment that performs similar functions, but is sold under a different brand name, is acceptable. Vendors are provided for reference. All instruments, including velocity sensors, should have tolerances within +/- 1%. **Note:** Equipment should be calibrated at least once a year to compensate for variation over time.

Equipment Name/Type	Serial / Models Number	Function	Vendor Contact
Robic Stop Watch	56964 / SC-505	Timer	
Cambridge Airflow Temperature Monitor  Kit contains: <ul style="list-style-type: none"> <li>▪ ATM-24 instrument</li> <li>▪ Accutrac Software (PC only) or Kermit (Mac only)</li> <li>▪ 5V Universal Power Supply with AC power cord</li> <li>▪ RS-232 cable</li> <li>▪ Carrying case</li> <li>▪ Plastic mounting clips for CAFS sensor</li> <li>▪ CAFS probes (as ordered)</li> </ul>	0135-992832-001 / ATM24  CAFS – 200 – SIOM (probes)	Measure airflow and temperature at multiple locations simultaneously	Cambridge Accusense, Inc. (978) 425-2090 <a href="mailto:sales@accusense.com">sales@accusense.com</a>
Extech True RMS Power Analyzer	NA / 380801	Measure amps, watts, power factor, voltage	(781) 890-7440 <a href="http://www.extech.com">www.extech.com</a>
Magtrol	6510E		<a href="http://www.magtrol.com">www.magtrol.com</a>
Vaisala Pressure transmitter	W3310001 / PTB100A	Temperature and humidity sensor	<a href="http://www.vaisala.com">www.vaisala.com</a> Barometric Pressure page (fixed transmitters)
Yokogawa	EJA310A		<a href="http://www.yokogawa.com/tm">www.yokogawa.com/tm</a>
Shimpo Digital Tachometer	10049812 / DT-5TG	Infrared beam counter	Shimpo Instruments Division of NIDEC-Shimpo America Corporation (630) 924-7138
Shimpo Retro-Reflective Beam Sensor	H9 / RS-220H		
Omron	E3S-CT61		

Actuator Company of America – Actuator Arm	NA / 1129	Holds CAFS probes	(408) 749-8204 <a href="http://www.actuator.net/actuators.htm">www.actuator.net/actuators.htm</a>
KB Indexing and Cycling Control	NA / KBPI-24OD(R)(8501)	Drive for actuator	KB Electronics, Inc. (800) 221-6570 <a href="mailto:info@kbelectronics.com">info@kbelectronics.com</a>
Testing cylinders	60" CFM Aluminum Chamber TD#8067*	Testing cylinders	Custom Projects Inc. 333 E. Brooks Rd. Memphis, TN 38109 Tel: 901-396-7398 Fax: 396-396-7399 Contact: Randy Jones

\* Ordering of multiple sized cylinders should be considered to accommodate more than one fan size.

## CHAPTER 3

### Air Delivery Room Construction and Preparation

#### 3.1 Air Delivery Room Requirements

The air delivery room, or testing chamber, shall be constructed per the blueprint provided in Appendix D. The room dimensions are recommended to be approximately 20 ft. x 20 ft. with an 11 inch high ceiling. **Note:** The control room shall be constructed external to the air delivery room.

The ceiling shall be constructed of sheet rock or stainless plate. The walls shall be of adequate thickness to maintain temperature and humidity during the test. It is important that the type of paint used on the walls, as well as the wall material, not absorb humidity while keeping the temperature of the room consistent at the time of testing. Oil based paint, which prevents absorption of humidity in the room, is preferred although other means of controlling humidity and temperature are acceptable.

#### **Room Ventilation**

The room shall have no ventilation other than the air conditioning and return. The air conditioning is used to control the temperature and humidity of the room (see Chapter 4 for requirements). At the time of construction of the room, means should be provided to close the air conditioning vents inside the room to ensure consistent air circulation patterns within the room.

Closing all vents during testing increases the accuracy of air flow and the reading of the air velocity sensors. It is therefore, recommended that air conditioning vents be closed during testing. **Note:** It is preferred to have electronically operated damper doors for the vents that can be controlled from a switch outside of the testing room.

#### 3.2 Equipment Set-Up

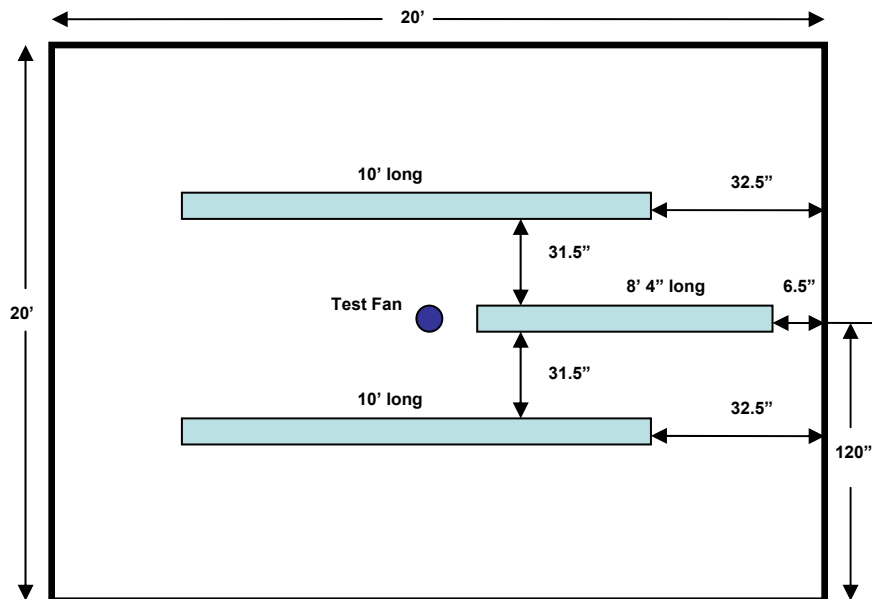
#### **Supportive Ceiling Rails**

The ceiling rail tracks, used to support and move the testing cylinder, shall be installed as shown in Figures 3.1 – 3.3.





**Figure 3.1 – Rail Track in Ceiling**



**Figure 3.2 – Rail Measurements and Details**



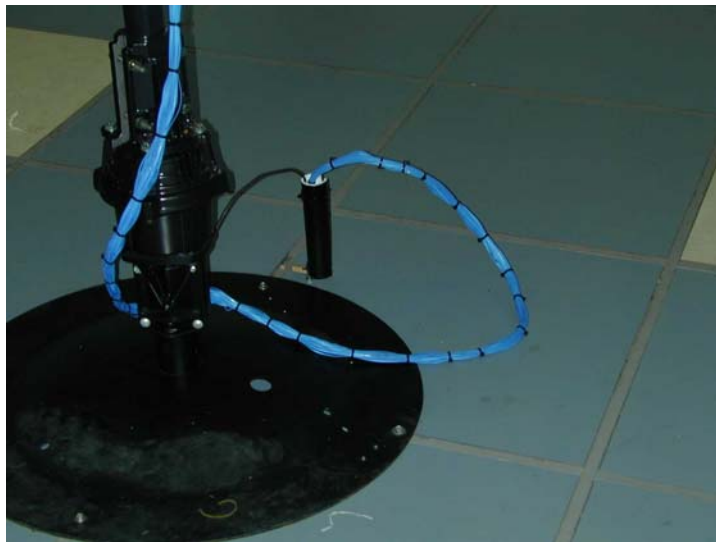
**Figure 3.3 – Test Cylinder and Rail Track Support**

### **Wiring**

The amount of exposed wiring shall be minimized. All sensor lead wires should be stored under the floor, if possible (Figure 3.4, below).

### **Sensors and Sensor Rotating Arm**

The sensors shall be placed at exactly 4-inch intervals. Sensor placement is shown in Figure 3.5, below. **Note:** It is extremely critical that the actual sensor not be touched prior to testing. Enough sensors shall be used to record air delivery to the end of the testing cylinder as shown in Figure 3.6.



**Figure 3.4 – Arm Rotator with Sensor Wires Covered**



**Figure 3.5 – Sensors Mounted in Testing Position**



**Figure 3.6 – Sensors and Sensor Rotating Arm**

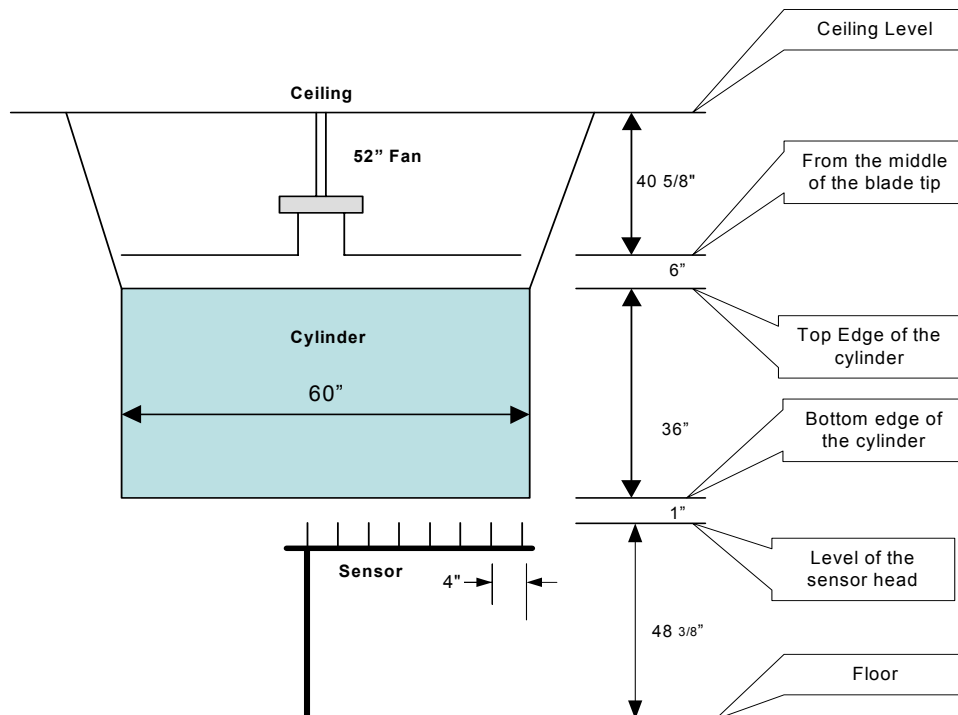
### **Test Cylinders**

The test cylinder hangs from the ceiling rails as shown in Figure 3.3. Test cylinders must be eight inches (diameter) larger than the fan model being tested. For example, a 52-inch fan should be tested within a 60-inch cylinder. Proper cylinder set-up is shown in Figures 3.7 – 3.9, below. Table 3.1 (refer to page 12) shows the appropriate cylinder size and number of sensors to use for each fan size. **Note:** If during set-up it is discovered that not all of the blades meet the 6" height above the cylinder requirement, an average shall then be taken of all of the blade heights, which then must meet the 6" requirement. While determining

the average height, the maximum variation in height of each individual blade from the edge of the cylinder should be limited to 0.5". If this is exceeded, the manufacturer shall then be required to send another fan for testing.



**Figure 3.7 – Testing Cylinder, Actuator, and Sensor Rotating Arm**



**Figure 3.8 – Air Delivery Room Set-Up with 60" Cylinder**



**Figure 3.9 – Testing Cylinder and Chamber**

Fan Size (in.)	Cylinder Diameter (in.)	Number of Sensors	Comments	Circle area factor of last sensor
36	44	6		
42	50	7	The effective area of last sensor will have circle width of 3"	3.0761
44	52	7		
48	56	7	The effective area of last sensor will have circle width of 6"	6.5449
52	60	8		
56	64	8	The effective area of last sensor will have circle width of 6"	7.5922
60	68	9		

**Table 3.1 – Cylinder and Sensor Selection Guide**

## CHAPTER 4

### Equipment Set-Up and Test Procedure

This chapter provides general instructions on setting up the equipment and performing the ceiling fan test. Lab personnel shall refer to equipment manuals for specific instructions.

#### 4.1 General Instructions

Listed below are some important things to remember when testing:

- The temperature and humidity setting shall be 76 $\pm$ 2 degrees F, 50 $\pm$ 5 percent relative humidity – these shall be held constant during entire test process (Figure 4.1)
- Allow the sensors to be turned on and the fan to run for 15 minutes at each fan speed/setting before taking readings.
- If present, light fixture should be turned off during testing.



**Figure 4.1 – Temperature and Humidity Sensors in Testing Room**



**Figure 4.2 – Tachometer Set-Up**

#### 4.2 Tachometer Set-Up

The installation of the RPM meter, or tachometer, is shown in Figure 4.2, above.

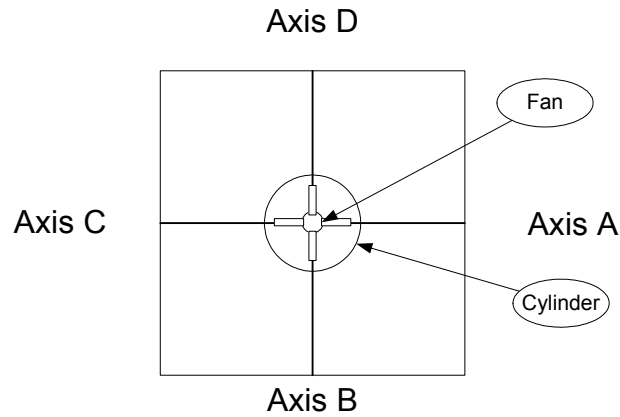
#### 4.3 Fan Set-Up and Testing Procedure

**Step 1:** Make sure the transformer power is off. Hang fan at the actuator hanging system and connect black and white wires from ceiling to fan. Ignore other wires, until further notice. **Note:** Fan will need to be assembled prior to the test; it is important that lab personnel follow the instructions provided by the fan manufacturer.

**Step 2:** Slide the metal cylinder to the center such that the fan is hanging above and exactly in the center of the cylinder. As mentioned in Chapter 3, test cylinders must be a total of eight inches larger than the fan model being tested.

**Step 3:** Adjust the actuator such that the middle of the blade tip is six inches above the top edge, or lip, of the metal cylinder (see note on p. 10). If necessary, use the Penta-Drive hoist's toggle switch and adjust height.

**Step 4:** Set the sensor arm to 0 degree Position (Axis A). Axis B, C and D are at 90, 180 and 270 degree positions, respectively of the arm. If necessary, use black tape marking as reference. To adjust beam alignment use antenna rotator by pressing the **LEFT** and **RIGHT** rocker switch. **Note:** Axis A – D can be designated either by using the four walls or four corners of the room. It is important that all axis points are equidistant from one another. See Figure 4.3 on the next page.



**Figure 4.3 – Testing Room and All 4-Axis**

#### 4.4 Accutract Software Instructions: Reading the Sensors

- Connect sensors as instructed in the Cambridge Airflow Temperature Monitor instruction manual
- The setting of the software shall be as follows (appropriate COM port of computer):
  - Statistics: Avg., Min., Max.
  - Probe: Gen'd
  - Prob Grid: (0X0)
  - Reading Interval: 1 second
  - Option Menu: (Altitude compensation: enter altitude, time unit second, airflow units FPM)



**Figure 4.4 – Ceiling Fan Testing Set-Up**



## 4.5 CFM Testing Procedure

Listed below are the basic steps during the ceiling fan test. Figure 4.4, on the previous page, shows a ceiling fan during an air delivery test.

**Step 1:** Rotate the sensor arm to Axis A.

**Step 2:** Load Accutrac Software. **Note:** The software shall be set up for 1 sec reading and for air velocity only, not for temperature. Insert current barometric pressure.

**Step 3:** Allow test fan to run 15 minutes at rated voltage and frequency (speed), close all doors and turn off all environmental conditioning equipment entering the chamber (e.g., air conditioning), wait an additional 3 minutes prior to starting test session. **Note:** Efforts should be made to ensure that temperature and humidity readings are held within the required tolerances (see Chapter 4, section 4.1) the duration of the test (all speeds). For example, it may be helpful to turn on environmental conditioning equipment between test sessions to ready the room for the following speed test.

**Step 4:** Start the session and begin recording readings. Take 100 readings (100 seconds run-time) and save the file to Data A. **Note:** When the session has started recording, make sure that only FPM are recorded; there is not need to record temperature readings.

**Step 5:** Similarly take the readings in Axis B, C, and D; these files will be saved as Data B, Data C, and Data D, respectively.

**Step 6:** Take the average value of each sensor and fill in the appropriate calculation spreadsheet shown in Appendix C.

## CHAPTER 5

### Calibration Approval and Reporting Test Results

#### 5.1 Approval to Begin Testing for ENERGY STAR

Before accepting and testing fans for ENERGY STAR testing, the following requirements must be met:

- Review all ENERGY STAR Documents

All testing facility personnel are required to review this testing guidance manual, and blueprints, as well as the ENERGY STAR Eligibility Criteria (Appendix A) and Qualified Product Information Form (Appendix B).

- Test Facility Site Inspection

As mentioned in Chapter 1, facilities that have not previously been accredited or recognized by an independent laboratory certification organization (e.g., UL, Intertek Testing Services) will require a facility site inspection by EPA and approved laboratory representatives. Facilities will be asked to provide proof of lab approval or recognition to be relieved of this requirement. EPA should be notified when the construction of a test facility has been completed and requires an inspection.

- Fan Calibration

To ensure consistency between all participating laboratories, each proposed testing facility must calibrate with one of the existing testing laboratories (i.e., those that have been approved to test ceiling fans for ENERGY STAR qualification). The proposed testing facility must request from EPA a Standard (52") Calibration Fan. EPA will ship Standard Calibration Fan to an existing testing laboratory for calibration. The existing testing laboratory will then ship the Standard Calibration Fan to the proposed testing facility for calibration. Once the calibration is complete, the proposed testing facility must return the fan to EPA. **Note:** proposed testing facility must bear all shipping costs by setting up an account number for use by EPA and the existing testing laboratory or by providing the required shipment paperwork with the request. Air delivery results at the proposed testing facility **must be within +/- 3%** of the existing testing laboratory results.

Calibration instructions:

1. Assemble fan according to directions provided by existing testing laboratory. **Note:** it is important to follow directions as to where to attached blades and brackets. These locations will be numbered and documented by existing testing laboratory.
2. Hang the Standard Calibration Fan in the air delivery room.

3. Set-up the testing as described in the **CFM Testing Procedure**.
4. Adjust the voltage input to the motor such that the RPM is exactly 200 RPM.
5. Take the air delivery reading in all of the four quadrants of the cylinder.

**Important Note:** Recalibration among all testing laboratories is likely to occur in the future, preserving the integrity of the Standard Calibration Fan is especially important. Any type of impact or mishandling can alter future calibrations. Handle the motor and blades carefully. Likewise, when shipping the Standard Calibration Fan, all efforts shall be made to protect the fan during shipping (i.e., use of bubble wrap, etc.).

- Calibration Approval

Calibration results shall be sent to EPA along with a cover letter requesting approval. The calibration results shall be submitted via the form provided in Appendix C of this manual. Once the calibration results are reviewed and approved by EPA, the testing facility will receive a memo stating that the facility may begin testing ceiling fans for ENERGY STAR qualification. The testing facility name will then be added to the ENERGY STAR Web site Qualified Laboratory List. **Note:** EPA reserves the right to ask for a recalibration of all testing facilities in the future.

## 5.2 Reporting Test Results and Other Tips

Under the ENERGY STAR Program Requirements for Residential Ceiling Fans, manufacturers must provide testing documentation when submitting products for ENERGY STAR qualification. A full report shall be provided for each test run to the manufacturer. Again, all lab personnel shall be familiar with the reporting requirements provided in the ENERGY STAR specifications (Attachment A) prior to testing for ENERGY STAR qualification. Fan testing results must be recorded and presented in a format similar to that provided in Appendix C, of this manual.

In addition, there are a number of important requirements that lab personnel should be aware of and communicate to the manufacturer. These are listed below.

- Lighting Requirements

Under the ENERGY STAR specification, a ceiling fan model that will be sold with an attached or integral light kit must be tested with the light source mounted in its' intended position and switched off. If a ceiling fan model is sold both with and without a light kit, two separate tests must be performed. It is very important that lab personnel indicate on the testing results form whether or not the fan tested includes lighting.

In addition to the fan testing, the lighting itself is required to be tested under the ENERGY STAR Residential Light Fixtures program. Ceiling fan testing facilities are

not required to provide this type of testing documentation; however laboratory personnel needs to be familiar with the requirement to test the light kit separately at a National Voluntary Laboratory Accreditation Program (NVLAP) accredited laboratory.

It is important to inform the customer of these additional lighting requirements ahead of time to avoid delays in qualification.

- Other Testing Considerations and Recommendations

Ceiling fan models that are the same in every aspect but finish may qualify under the representative model that is tested. Differences in construction such as housing, blade pitch, and motor could affect air movement and require separate testing. This testing procedure is intended to provide fan performance results for the complete ceiling fan model and shall not be used as a means to test individual components. Therefore, fans that DO NOT pass shall be sent back to the customer and a new fan submitted for qualification. Laboratory personnel shall not accept new components from a customer for means of a re-test.

Laboratory facilities may be asked to test a ceiling fan in response to an industry challenge. This occurs when one manufacturer challenges the test results of another manufacturer's product. In this case, EPA will ask one of the testing facilities to purchase the product and perform a complete test. Costs for the fan purchase, shipment, and testing will be covered by one of the two manufacturers, depending on the results. Results of the test shall be sent to EPA for review. Additional information on challenges, can be found in the specification provide in Attachment A (Section 4: Test Criteria, Reporting Requirements).

Lab personnel shall also indicate the condition in which the fan was received, discrepancies in model numbers, and other concerns or inconsistencies.

## CHAPTER 6

### Definitions and Acronyms

#### 6.1 Definitions

**Actuator:** Mechanism that puts something into automatic action; motor driven. For purposes of this test procedure, the actuator holds and controls the height of the fan above the test cylinder.

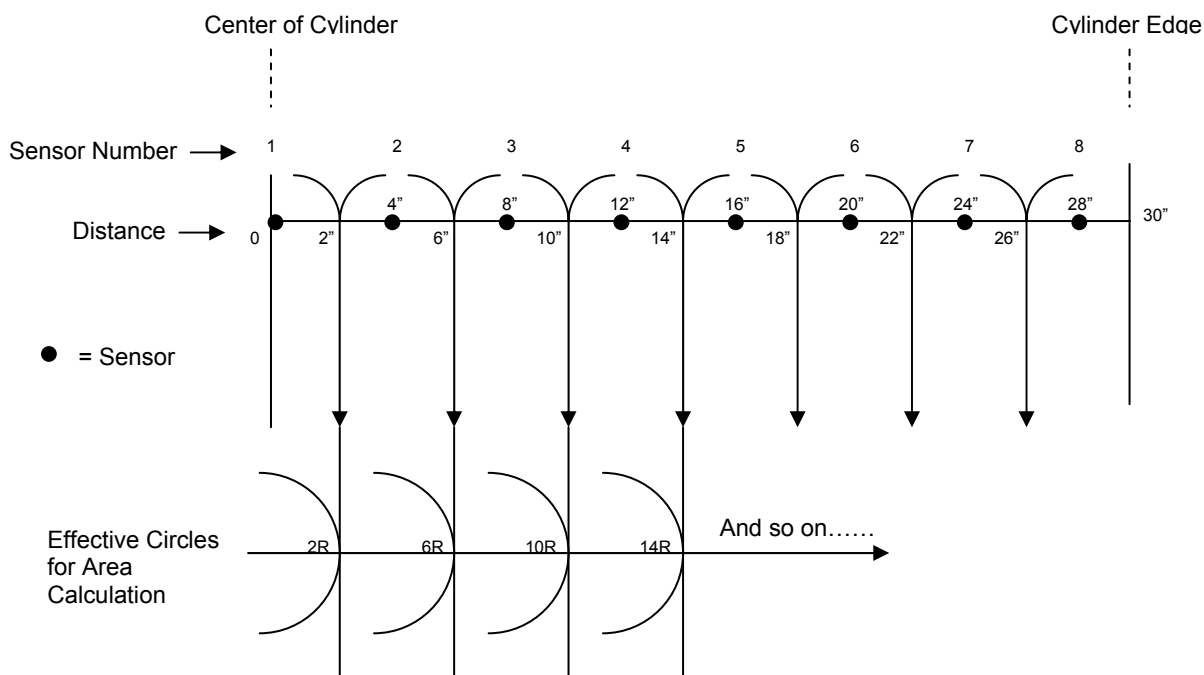
**Airflow:** The rate of air movement at a specific fan speed setting expressed in cubic feet per minute (CFM).

**Airflow Efficiency:** The ratio of airflow divided by power at a specific ceiling fan speed setting expressed in CFM per watt (CFM/watt).

**Attachable Light Kit:** Equipment that is used to provide light from the ceiling fan, and is not physically attached to the fan at the time of sale.

**Blade Pitch:** The angle between the fan's blades and the horizon.

**Circle Area:** Circular area over which the sensor can detect and record air delivery from a testing cylinder. For purposes of this test procedure, the following calculation was performed to determine circle area (see picture below):



Sensor #1 at 0"       $\pi (2/12)^2 = 0.0873 \text{ ft}^2$   
 Sensor #2 at 4"       $\pi [(6/12)^2 - (2/12)^2] = 0.6981 \text{ ft}^2$   
 Sensor #3 at 8"       $\pi [(10/12)^2 - (6/12)^2] = 1.3963 \text{ ft}^2$

**COM Port:** Of a device or network, a point of access where signals may be inserted or extracted, or where the device or network variables may be observed or measured; ability to communicate with external devices.

**Damper:** A device that decreases the amplitude of electronic, mechanical, acoustical, or aerodynamic oscillations. For purposes of this test procedure it is an airtight door that prevents external airflow into the testing room.

**Fan Housing:** The decorative body of the fan which encloses the motor.

**Fan Motor:** Device that turns the ceiling fan blades in order to move air.

**Fan Size:** Total diameter (circumference) of blade span; measured in inches at the blade tips.

**Integral Light Kit:** Equipment that is used to provide light from the ceiling fan, and is connected to the fan at the time of purchase. For purposes of this test procedure, the integral light kit must be attached at the time of testing.

**Infrared Beam:** Beam of light situated outside the visible spectrum at its red end, having a wavelength between about 700 nanometers and 1 millimeter; longer than visible light but shorter than radio waves. Infrared beam is used within the Tachometer to count the revolutions per minute (RPM).

**Representative Fan Model:** Prototype or fan model that is tested to qualify a line of products under the same model name and number. Those fans represented by this model must be the same in every aspect but finish.

**Sensor:** An electronic device used to measure a physical quantity such as temperature, pressure, loudness, or airflow and convert it into an electronic signal of some kind. Sensors are normally components of some larger electronic system such as a computer control and/or measurement system.

**Solid State Test Method:** Test method that specifies the apparatus and testing protocol for measuring a residential ceiling fan's airflow and power consumption. The method, developed by Hunter Fans, utilizes a thermister based hot-wire anemometer and requires a temperature controlled room and computer for recording test data.

**Tachometer:** Device that measures rotational motion; a speed indicator. Measurement is usually in revolutions per minute (RPM).

**Third Party Testing Facility:** Independent test facility that is not affiliated with the manufacturer.

## 6.2 Acronyms

CFM	Cubic feet per minute
EPA	Environmental Protection Agency
FPM	Feet per minute
ITS	Intertek Testing Services
NVLAP	National Voluntary Laboratory Accreditation Program
RMS	Root Mean Square
RPM	Revolutions per minute
UL	Underwriters Laboratory

## **APPENDIX A**

### **ENERGY STAR Program Requirements for Residential Ceiling Fans: Eligibility Criteria**





# ENERGY STAR® Program Requirements for Residential Ceiling Fans

## Eligibility Criteria

Below is the product specification (Version 1.1) for ENERGY STAR qualified residential ceiling fans. A product must meet all of the identified criteria if it is to be labeled as ENERGY STAR by its manufacturer.

- 1) **Definitions:** Below is a brief description of a ceiling fan and other terms as relevant to ENERGY STAR.
  - A. **Residential Ceiling Fan:** A non-portable device designed for home use that is suspended from the ceiling for circulating air via the rotation of fan blades. Some ceiling fans also have an integral or attached light kit.
  - B. **Light Kit:** A light kit is the equipment used to provide light from a ceiling fan. Light kits can be:
    - Integral – the light kit arrives hardwired to the ceiling fan
    - Attachable – the light kit is not, at the time of sale, physically attached to the fan. The light kit must be attached to the ceiling fan for the lights to work. Attachable light kits might be included inside the ceiling fan box at the time of sale or sold separately for subsequent attachment to the fan.
  - C. **Controls:** Controls enable the user to turn on/off or adjust the lighting and fan movement. Controls can be in the form of pull chain, slide switch, wall switch/panel, or remote control.
  - D. **Airflow:** The rate of air movement at a specific fan setting expressed in cubic feet per minute (CFM). Airflow is determined from testing done using the Solid State Test Method, defined below.
  - E. **Airflow Efficiency:** The ratio of airflow divided by power at a specific residential ceiling fan setting expressed in CFM per watt (CFM/watt). Airflow and power are determined from testing done using the Solid State Test Method, defined below.
  - F. **Power Consumption:** The active power expressed in watts. Power consumption is measured during residential ceiling fan testing at a specific speed using the Solid State Test Method, defined below.
  - G. **Standby Mode:** Mode when the lights are off and the fan blades are not rotating.
  - H. **Solid State Test Method:** A method developed by the Hunter Fan Company that specifies the apparatus and testing protocol for measuring a residential ceiling fan's airflow and power consumption. The method utilizes a hot-wire anemometer and requires a temperature controlled room and computer for recording test data.
  - I. **Hugger Fans:** Ceiling fans that are installed directly against the ceiling.
- 2) **Qualifying Products:** For the purposes of ENERGY STAR, the following two types of residential ceiling fans may qualify: those sold with light kits and those sold without light kits. **Hugger fans are not currently eligible for participation in ENERGY STAR for Residential Ceiling Fans as a result of the testing process producing efficiency and performance levels substantially greater than**

what the fans will normally deliver in residential use. Data will be collected regarding hugger fans and the inclusion of such fans will be reevaluated for Tier II of these specifications.

- 3) Energy-Efficiency Specifications for Qualifying Products: Only those products listed in Section 2 that meet the criteria below may qualify as ENERGY STAR.

A. Airflow Efficiency

Qualifying products shall meet or exceed the following requirements for total airflow and for airflow efficiency when operating in a downward-blowing direction. Models sold with light kits or integrated light sources must be tested with those light sources mounted in their intended position and switched off. Individual models' measured performance may vary by +/- 5 percent and still be deemed compliant with this specification.

<b>Table 1 – Tier I Specifications for Air Flow Efficiency</b>		
<b>Fan Speed</b>	<b>Minimum Airflow</b>	<b>Efficiency Requirement</b>
Low	1,250 CFM	155 CFM/watt
Medium	2,500 CFM	110 CFM/watt
High	5,000 CFM	75 CFM/watt

Note: No standby power requirements are included in Tier I specifications.

<b>Table 2 – Tier II Specifications for Air Flow Efficiency</b>		
<b>Fan Speed</b>	<b>Minimum Airflow</b>	<b>Efficiency Requirement</b>
Low	TBD	TBD
Medium	TBD	TBD
High	TBD	TBD

Note: Under Tier II, fans may consume no more than 1 watt of power in standby mode. These standby requirements are included in Tier II to ensure that remote control circuits, if included, operate efficiently.

Airflow and efficiency requirements for Tier II may be divided into separate categories by fan diameter if data collected in 2002 indicate clear differences in achievable performance among fans of different sizes. Likewise, the Tier II specification may include consideration of power factor if warranted by product performance and utility request.

This specification defines residential ceiling fan airflow efficiency on a performance basis: CFM of airflow per watt of power consumed by the motor and controls. This treats the motor, blades, and controls as a system, allowing multiple approaches to reach a given efficiency level. Efficiency is to be measured on each of three fan speeds (low, medium and high) using the "Solid State Test Method" which was developed by Hunter Fan Company and is explained in more detail in Section 4, Test Criteria. Residential ceiling fans capable of operating at more than three speeds must meet the above levels at any three of those total speeds, though measurements should be taken and reported for all discrete operating speeds.

B. Controls

**Tier I**

Under Tier I, qualifying products shall permit convenient consumer adjustment of fan speed. This may be accomplished by means of one or more wall-mounted switch(es), a remote control, or readily accessible pull chains. For purposes of this specification, "readily accessible" shall be defined as a length sufficient to reach a height of no more than 80 inches above the floor when the residential ceiling fan is mounted according to the residential ceiling fan's installation instructions. For those residential ceiling fans that can accommodate lighting, the lights and the fans must be controllable

separately, allowing users to switch off lights during fan operation or operate the lights without using the residential ceiling fan.

## **Tier II**

In addition to meeting the requirements under Tier I, qualifying products shall provide for consumer adjustment of airflow direction (upward or downward) by one of the following means:

- A vertically mounted slide switch on the motor housing, in which the downward position corresponds to downward airflow
- A wall-mounted switch
- A remote control
- A readily accessible pull chain

## **C. Lighting**

### **Tier I**

Qualifying residential ceiling fans sold with integral or attachable light kits must meet one of the following requirements:

- Pin-Based Approach – The residential ceiling fan lighting systems shall meet the requirements of the ENERGY STAR specification for residential light fixtures; or
- Screw-Based Approach – The number of ENERGY STAR qualified screw-based bulbs needed to occupy each standard Edison-based socket shall be included within the residential ceiling fan packaging.

Qualifying residential ceiling fans sold without integral or attachable light kits need not meet any additional lighting requirements.

### **Tier II**

Qualifying residential ceiling fans sold with integral or attachable light kits must meet the requirements of the ENERGY STAR specification for residential light fixtures.

Qualifying residential ceiling fans sold without integral or attachable light kits must provide information on product packaging or with product instructions regarding ENERGY STAR qualifying light kits that may be used with that particular residential ceiling fan.

**EPA recommends that manufacturers pursue the pin-based approach in both Tier I and Tier II, because it will tend to yield greater energy savings and performance, lower consumer cost, and fewer complications with retailers than the screw-based approach.**

## **D. Noise**

### **Tier I**

None

### **Tier II**

Qualifying products shall meet the following maximum standards for operational noise:

<b>Table 3 – Tier II Specifications for Operational Noise</b>	
<b>Fan Speed</b>	<b>Minimum Sound Pressure Level (SPL)</b>
Low	TBD
Medium	TBD
High	TBD

In addition, qualifying products shall include a standardized label on the product package noting operational noise in dB at each of three operating speeds, measured by a method agreed to by all manufacturers that participate in ENERGY STAR for Residential Ceiling Fans. That method shall be finalized no later than October 1, 2002.

Each fan speed will be associated with a minimum airflow in CFM. The final Tier II specification will state a test procedure for measuring fan noise. This specification will need to address, among other things: test chamber size and characteristics, type of measurement equipment, and type of sound being measured. The specification could either measure total SPL or attempt to specify the particular harmonics that result from electrical and mechanical fan noise, but are not the product of wind noise from the blades. Allowable noise levels will be higher for higher fan speeds.

E. Warranty

**Tier I**

Qualifying products shall provide a warranty of at least 30 years for the motor and at least one year for all other components of qualifying residential ceiling fans. Residential ceiling fans sold with integral light kits shall also meet applicable warranty requirements for ENERGY STAR labeled residential light fixtures.

**Tier II**

No additional requirements

F. Consumer Information

**Tier I**

In addition to the ENERGY STAR label, packaging of ENERGY STAR qualified residential ceiling fans shall also state airflow, fan power consumption, and airflow efficiency at each of their three operating speeds, as determined by the test procedures specified in Section A, Airflow Efficiency. This information shall appear in the following form on the outside portion of the package:

<b>Fan Speed</b>	<b>Airflow</b>	<b>Fan Power Consumption (without lights)</b>	<b>Airflow Efficiency (higher is better)</b>
Low	__ CFM	__ watts	__ CFM/watt
Medium	__ CFM	__ watts	__ CFM/watt
High	__ CFM	__ watts	__ CFM/watt

Product operating and installation instructions shall include a short list of standardized information regarding how to operate the products efficiently. This list shall include, at a minimum, information about the following topics:

- adjusting fan speed and direction for season and room occupancy to maximize energy savings
- HVAC thermostat adjustment for energy savings when a ceiling fan is in use
- proper mounting distance from the ceiling to maximize efficient operation
- how to find proper replacement lamps for the light kit, if included

## Tier II

No additional requirements

- 4) **Test Criteria:** Manufacturers are required to perform tests and self-certify those product models that meet the ENERGY STAR guidelines. In performing these tests, manufacturers must use Hunter's Solid State Test Method described below.

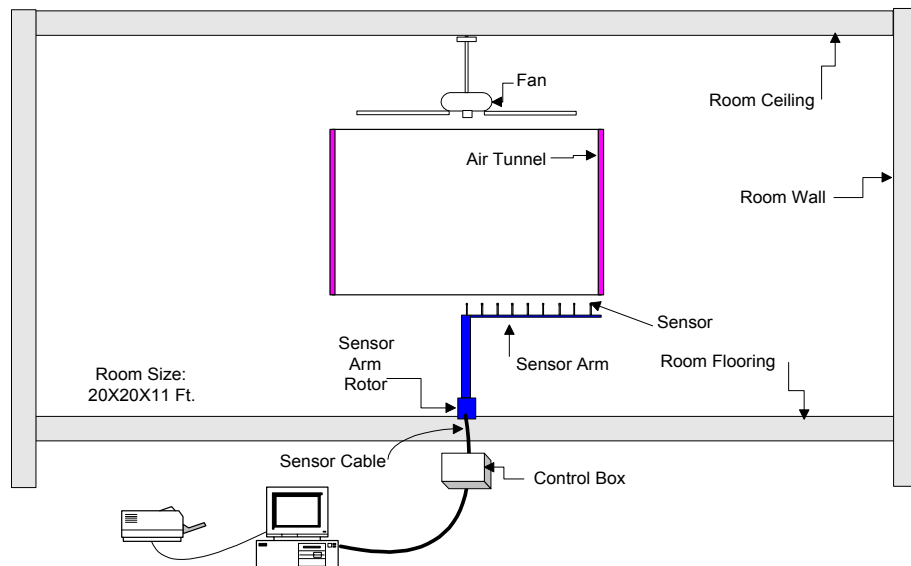
### Solid State Test Method

The methodology behind the Solid State Test is designed to increase efficiency and improve accuracy. It provides an accurate representation of the air circulation created by the fan in the room. The method reduces the testing and validation time to a fraction of the time period required by NEMA or IEC standards.

The room details and the setup for ceiling fan testing by the Hunter method is explained in the illustration, below.

A fan is hung above the predefined tunnel or a large diameter tube in a standard temperature and humidity controlled room. The air delivered by the fan is made to pass through the tunnel. At the end of the tunnel, a row of velocity sensors is mounted on a rotating arm. The airflow at various points in the tube is measured simultaneously and instantaneously for several seconds. The average reading of air velocities is then used to compute the air delivery by calculations similar to IEC and NEMA suggested methods.

The important characteristic of the Solid State Test Method is the use of the latest method of measurement of air velocities by multiple probes. Instead of moving a mechanical or an electronic probe from point to point to measure the airflow (velocity), this method allows you to perform simultaneous monitoring of air velocity instantly. The information is recorded in real time and can be analyzed as the measurement is being taken. The probes utilize the time-tested technology of hot wire thermister anemometry. Each probe has a temperature and cooling rate sensor. The signal from these sensors is fed into the computer via the control box. Using the appropriate software, calculations are made to compute the air delivery of the fan. This multi-point measurement of airflow velocity as well as air surface temperature analysis is a crucial step in the development of this method. The complete test takes under two minutes, not including the time to hang the fan.



Hunter Air Delivery Measurement Room Setup

## Reporting Requirements

The company whose brand name appears on the product packaging shall, for purposes of this specification, be considered the manufacturer. Manufacturer must complete a Qualified Product Information form when submitting qualified products to EPA. This form must be accompanied by reports from a qualified laboratory containing airflow, power consumption, and airflow efficiency data for each residential ceiling fan model proposed for labeling. Families of residential ceiling fan models that are identical in every respect but housing and blade finish may be qualified through submission of test data for a single representative model. Likewise, models that are unchanged or that differ only in housing or blade finish from those sold in a previous year may remain qualified without the submission of new test data. However, separate test data are required for all models that differ in any of the following characteristics:

- motor type or size
- rotational speed
- control type (if included with fan)
- blade weight, number, size, or pitch

Any manufacturer or EPA may challenge the test results for a particular product. Under the rules of a challenge, an independent laboratory recognized by EPA will purchase a sample of the challenged product from a US retail store and conduct a set of measurements. If the testing of this sample meets the requirements of the ENERGY STAR specification, the challenger must pay for the cost of the independent laboratory test.

If the sample fails to meet those requirements, its manufacturer must pay for the cost of the independent laboratory test. Failure to pass the challenge will result in further investigation by the EPA. The EPA may request minor modifications or other actions by the manufacturer to meet the labeling requirements. If the product does not meet the requirements of the EPA investigation, it may be removed from ENERGY STAR's qualified product list.

## Laboratory Testing

Manufacturers may elect to use a qualifying in-house or independent laboratory to provide these results. Qualified laboratories will conduct "round-robin" testing at least every six months with identical fan samples to verify that they can consistently obtain results for CFM/watt within +/- 3 percent of each other for testing done on the same fan. Qualifying test facilities will be provided on the ENERGY STAR Web site at [www.energystar.gov](http://www.energystar.gov).

- 5) Effective Date: The date that manufacturers may begin to qualify products as ENERGY STAR will be defined as the *effective date* of the agreement.

Tier I: The first phase, Tier I, shall commence on January 1, 2002 and conclude on September 30, 2003. Partners can qualify ceiling fan models for Tier I starting January 1, 2002. All products shipped after this date and through September 30, 2003 must meet Tier I requirements in order to bear the ENERGY STAR label.

Tier II: The second phase, Tier II, shall commence on October 1, 2003. Specifications for Tier II shall apply to products that are shipped after September 30, 2003. All products, including models originally qualified under Tier I, shipped after this date must meet Tier II requirements in order to bear the ENERGY STAR label (including additional shipments of models originally qualified under Tier I). Final revisions to Tier II specifications will be completed in late 2002, to provide manufacturers sufficient lead time for making needed product revisions.

- 6) Future Specification Revisions: ENERGY STAR reserves the right to change the specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through industry discussions.

## **APPENDIX B**

### **ENERGY STAR Qualified Product Information Form**



## Qualified Product Information Form for Residential Ceiling Fans



**ENERGY STAR® Product Information Form for Use by ENERGY STAR Labeled Residential Ceiling Fan Partners  
(Companies who have joined ENERGY STAR by signing a Partnership Agreement)**

*You may use this form to report only those products that are sold under the company's brand name. If your firm sells its models to another company that uses its own brand name, that company must join ENERGY STAR and report its own products. Information from this form will be added to the list of ENERGY STAR qualified residential ceiling fan products. Please copy this form and return one for each qualifying product model to the address below.*

**Company Name:** \_\_\_\_\_  
(As listed in Partnership Agreement)

**Product Contact Information**  
(verification of product information)

Product Type (check one): <input type="checkbox"/> Ceiling Fan only <input type="checkbox"/> Ceiling Fan with Light Kit – Pin Based CFLs <input type="checkbox"/> Ceiling Fan with Light Kit – Screw Based CFLs <input type="checkbox"/> Light Kit Only – Pin Based <input type="checkbox"/> Light Kit Only – CFLs
---

Name: \_\_\_\_\_

Tel: \_\_\_\_\_

Fax: \_\_\_\_\_

Email: \_\_\_\_\_

**Product Information** – List representative (tested) fan model first. If there are additional models that are identical to the representative model in every respect but housing and blade finish, they also may be listed in the table below.

Model Name	Model Number

**Airflow Efficiency**

Fan Speed	Airflow (CFM)	Fan Power Consumption (watts)	Airflow Efficiency (CFM/watt)

Controls

Provide type and location of fan controls (wall-mounted switch, pull chain, remote control):

Type of Fan Control	A. <u>Location of Fan Control</u>

Lighting Requirements (for fans sold with integral or attachable light kits)

**Pin-Based:** Light fixture must be tested and qualify under ENERGY STAR’s Residential Light Fixture (RLF) Eligibility Criteria. Please provide test results in Section VIII of this form. Testing documentation must be submitted with this form. **Note: If lamp ballast combination has already been tested by OEM, or other entity, you may use existing lab data and reports.**

**Screw-Based:** ENERGY STAR Qualified Compact Fluorescent Light Bulbs (CFLs) must be included in packaging.

Manufacturer \_\_\_\_\_ Model/Product # \_\_\_\_\_

CFL Wattage \_\_\_\_\_ Number of CFLs Included in Packaging \_\_\_\_\_

Warranty

Motor Warranty: \_\_\_\_\_ years

List Fan Components and their Warranties: \_\_\_\_\_

**Labeling Requirements**

Is product shipped with ENERGY STAR label:

\_\_\_\_\_ On product packaging/box (required)?                      \_\_\_\_\_ In product literature (required)?

\_\_\_\_\_ On Internet site (required)?

Is Performance and Efficiency Table clearly displayed on the outside of the product packaging (check one)?

Yes                       No

If the answer to any of the above is No, explain why: \_\_\_\_\_

Testing

All manufacturers are required to perform tests on residential ceiling fan models by using the Solid State Test Method described in the Program Requirements for Residential Ceiling Fans. Fan models identical in every respect but housing and blade finish may be represented by a single representative model for testing purposes. However, separate test data is required for all models that differ in motor type or size, rotational speed, control type, or blade weight, number, size, or pitch. **Laboratory test results must be attached to this form to qualify for the ENERGY STAR label.**

Tested By: \_\_\_\_\_  
(Name of Qualified Testing Facility)

Date Available (on market): \_\_\_\_\_

Residential Light Fixture Test Results

Model Number	Brand Name	Number of Lamps	Lamp Type	Lamp Wattage	Ballast Type (circle one)
					Electronic Magnetic

Performance Characteristic	Test Result (fill-in values)	Required Documentation
Efficacy	_____ Lumens	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory Attached?
	_____ Input Power (watts)	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory or from an OSHA NRTL attached?
	_____ Lumens Per Watt	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory Attached?
Power Factor	_____	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory or from an OSHA NRTL attached?
Lamp Current Crest Factor	_____	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory or from an OSHA NRTL attached?
Lamp Start Time	_____ Seconds	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory or from an OSHA NRTL attached?
Lamp Color Rendering	_____ CRI	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory Attached?
Lamp Correlated Color Temperature	_____ Kelvin	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory Attached?
Noise	_____ dBA	Ballast Manufacturer Data Attached?
Safety – Portable Fixtures	UL Listed?    Yes    No	OSHA NRTL Test Report Attached?
Safety – Hardwired Fixtures	UL Listed?    Yes    No	OSHA NRTL Test Report Attached?
Safety – Ballasts and “Fluorescent Adapters”	UL Listed?    Yes    No	OSHA NRTL Test Report Attached?
Operating Temperature	_____ degrees Celsius	Ballast Manufacturer Data Attached?
Ballast Frequency	_____ kHz	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory or from an OSHA NRTL attached?
Transient Protection	Test report from a lab accredited by NVLAP or an ILAC MRA Signatory or from an OSHA NRTL attached?	
End of Life Protection	Manufacturer Data Attached?	
Warranty	Written Warranty Attached?	
Dimming	Does fixture have dimming capability?	

## Additional Information

Please list all major retailers that carry the product (attach a list if necessary): \_\_\_\_\_

---

The Qualified Product Information Form and Program Requirements for Residential Ceiling Fans and the Program Requirements (Eligibility Criteria) for Residential Light Fixtures can be found on the ENERGY STAR Web site at [www.energystar.gov/library](http://www.energystar.gov/library).

For a list of qualifying CFLs, visit the ENERGY STAR Web site at [www.energystar.gov/products](http://www.energystar.gov/products), under “Lighting.”

Please submit your completed Qualified Product Information Forms and testing documentation one of the following ways:

**E-mail** testing results/QPI forms to Rebecca Miller at [rmiller@icfconsulting.com](mailto:rmiller@icfconsulting.com)

**Fax** results/QPI forms to Rebecca Miller at (202) 862-1144

**US Mail/Overnight/Express** results/QPI forms to: Rebecca Miller, ICF Consulting, 1850 K Street NW, Suite 1000, Washington, DC 20006

## **APPENDIX C**

### **Laboratory Reporting Form(s)**

Air Delivery Test
36" Fan

Test #	
Date of Test	
Test Conducted By:	

Model #	
Name	
Size	
Blade Description	

Relative Humidity (%)	
Room Temp (F)	
Barometric Pres. (PSI)	

Volts / Hz	
Watt	
Amp	
RPM @start	
Speed	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0					0.0873		
2	4					0.6981		
3	8					1.3963		
4	12					2.0944		
5	16					2.7925		
6	20					3.4907		
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								

Air Delivery Test
42" Fan

Test #	
Date of Test	
Test Conducted By:	

Model #	
Name	
Size	
Blade Description	

Relative Humidity (%)	
Room Temp (F)	
Barometric Pres. (PSI)	

Volts / Hz	
Watt	
Amp	
RPM @start	
Speed	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0					0.0873		
2	4					0.6981		
3	8					1.3963		
4	12					2.0944		
5	16					2.7925		
6	20					3.4907		
7	24					3.0761		
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								

Air Delivery Test
44" Fan

Test #	
Date of Test	
Test Conducted By:	

Model #	
Name	
Size	
Blade Description	

Relative Humidity (%)	
Room Temp (F)	
Barometric Pres. (PSI)	

Volts / Hz	
Watt	
Amp	
RPM @start	
Speed	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0					0.0873		
2	4					0.6981		
3	8					1.3963		
4	12					2.0944		
5	16					2.7925		
6	20					3.4907		
7	24					4.1888		
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								



Air Delivery Test
48" Fan

Test #	
Date of Test	
Test Conducted By:	

Model #	
Name	
Size	
Blade Description	

Relative Humidity (%)	
Room Temp (F)	
Barometric Pres. (PSI)	

Volts / Hz	
Watt	
Amp	
RPM @start	
Speed	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0					0.0873		
2	4					0.6981		
3	8					1.3963		
4	12					2.0944		
5	16					2.7925		
6	20					3.4907		
7	24					6.5449		
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								

Air Delivery Test
52" Fan

Test #	
Date of Test	
Test Conducted By:	

Model #	
Name	
Size	
Blade Description	

Relative Humidity (%)	
Room Temp (F)	
Barometric Pres. (PSI)	

Volts / Hz	
Watt	
Amp	
RPM @start	
Speed	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0					0.0873		
2	4					0.6981		
3	8					1.3963		
4	12					2.0944		
5	16					2.7925		
6	20					3.4907		
7	24					4.1888		
8	28					4.8869		
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								

<b>Air Delivery Test</b>
56" Fan

<b>Test #</b>	
<b>Date of Test</b>	
<b>Test Conducted By:</b>	

<b>Model #</b>	
<b>Name</b>	
<b>Size</b>	
<b>Blade Description</b>	

<b>Relative Humidity (%)</b>	
<b>Room Temp (F)</b>	
<b>Barometric Pres. (PSI)</b>	

<b>Volts / Hz</b>	
<b>Watt</b>	
<b>Amp</b>	
<b>RPM @start</b>	
<b>Speed</b>	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0						0.0873	
2	4						0.6981	
3	8						1.3963	
4	12						2.0944	
5	16						2.7925	
6	20						3.4907	
7	24						4.1888	
8	28						7.5922	
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								

Air Delivery Test
60" Fan

Test #	
Date of Test	
Test Conducted By:	

Model #	
Name	
Size	
Blade Description	

Relative Humidity (%)	
Room Temp (F)	
Barometric Pres. (PSI)	

Volts / Hz	
Watt	
Amp	
RPM @start	
Speed	

Sensor #	Sensor Dist. From Center (inch)	Velocity in FPM - Axis #				Average Vel. (FPM)=A	Circle area (sq. Ft.) = B	Air Delivery (CFM)=A*B
		A	B	C	D			
1	0					0.0873		
2	4					0.6981		
3	8					1.3963		
4	12					2.0944		
5	16					2.7925		
6	20					3.4907		
7	24					4.1888		
8	28					4.8869		
9	32					5.5851		
<b>Total Air Delivery (CFM)</b>								
<b>CFM/W</b>								

## **APPENDIX D**

### **Engineering Blueprints for Air Delivery Room**