DOCKETED

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Staff Supplement - Whole House Fan: Field Verification and Diagnostic Testing

Date: 2017-11-29

Pages: 4

Author: Jeff Miller

Subject: Proposed Whole House Fan Field Verification and Diagnostic Testing

BACKGROUND

Prescriptive whole house fan (WHF) requirements were first introduced in the 2013 version of Title 24, Part 6 (Standards), in Section 150.1(c)12, The WHF requirements remain in force for the 2016 version of the Standards, however the stringency for minimum airflow rate and attic vent free area was reduced for the 2016 version of the Standards. See excerpts from the 2013 and 2016 Standards language below.

From 2013 Standards Section 150.1(c)12:

12. **Ventilation Cooling**. Single family homes shall comply with the Whole House Fan (WHF) requirements shown in TABLE 150.1-A. When a WHF is required, comply with Subsections A. through C. below:

A. Have installed one or more WHFs whose total Air Flow CFM as listed in the CEC Directory is at least 2 CFM/ft^2 of conditioned floor area; and
B. Have at least 1 square foot of attic vent free area for each 375 CFM of rated whole house fan Air Flow CFM; and
C. Provide homeowners who have WHFs with a one page "How to operate your whole house fan" informational sheet.

From 2016 Standards Section 150.1(c)12:

12. **Ventilation Cooling**. Single family homes shall comply with the Whole House Fan (WHF) requirements shown in TABLE 150.1-A. When a WHF is required, comply with Subsections A. through C. below:

A. Have installed one or more WHFs whose total Air Flow CFM as listed in the CEC Directory is at least1.5 CFM/ft2 of conditioned floor area; and
B. Have at least 1 square foot of attic vent free area for each 750 CFM of rated whole house fan Air Flow CFM, or if the manufacturer has specified a greater free vent area, the manufacturers' free vent area specifications; and
C. Provide homeowners who have WHFs with a one page "How to operate your whole house fan" informational sheet.

Compliance with the Prescriptive WHF requirement for airflow rate is determined by the rated performance listed in the California Title 20 Modernized Appliance Efficiency Database System (MAEDBS) located by the URL below.

https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx

The MAEDBS reports:

- WHF manufacturer name,
- WHF brand name,
- WHF Model number,
- WHF type,
- WHF airflow rate in cubic feet per minute (cfm),
- WHF motor energy in Watts, and
- WHF efficacy in cfm per watt.

In 2015, one WHF manufacturer communicated to Energy Commission staff that a competitor's WHF airflow performance data in the Title 20 MAEDBS was not accurate. Subsequently Energy commission staff contracted to have field testing performed at five homes in Sacramento, CA. The results of these field tests are reported in Appendix A, and indicate that for the WHF models with published performance specifications, the airflow measured in the field for the WHF models who's performance was being challenged was 51%, and 42% of the manufacturer's total high speed published airflow ratings. A WHF model from a different manufacturer was also tested, performing at 90% of that manufacturer's total high speed published airflow ratings.

Subsequently, in 2016, the Energy Commission's Office of Compliance Assistance arranged for testing to be performed on two selected WHF products – one of these WHFs was selected from products from the manufacturer for which WHF airflow data in MAEDBS had been called into question by a competitor as mentioned above. These laboratory tests were conducted according to Home Ventilating Institute Publication 916 (HVI 916) in two different laboratories. The results of these laboratory tests are reported in Appendix B, and Appendix C and indicate the WHF model for which performance was being challenged by a competitor performed at 70% of the manufacturer's total high speed published performance data, and a different manufacturer's model performed at 94% of the manufacturer's total high speed published airflow ratings. Also, one of the WHFs was tested a second time at a different lab in order to validate the reliability of one of the tests. As a result of this laboratory testing, the performance ratings in the Title 20 MAEDBS listings for one of the WHF manufacturers were adjusted to a lower value for airflow rate.

WHF PERFORMANCE DATA IN THE TITLE 20 MAEDBS

The Title 20 Appliance Efficiency Regulations reference HVI 916 for the WHF method of test, for reporting the test results, and specify use of the test setup in section 5.2 of that standard, but do not specify rating WHFs according to Home Ventilation Institute Publication 920 (HVI 920). HVI 920 requires Whole House Comfort Ventilators (whole house fans) to be rated at a static pressure of 0.1 inch water because they are expected to overcome the resistance of attic outlet

vents. Title 20 does not specify a rating point in terms of static pressure. Thus Title 20 does not give direction for use of the results of the HVI 916 test procedure.

Also, there is no mandatory language in HVI 916 to direct use of HVI 920 for rating WHFs. Section 1.4 in HVI 916 provides guidance relevant to certification, and the relationship of HVI 916 to other HVI publications, stating further requirements for HVI product rating and certification using test reports from the HVI 916 procedure are described in HVI Publication 920.

At the time of this writing, the WHFs listed in the Title 20 MAEDBS are not listed in the HVI directory of certified products, with the exception of 5 WHF models from one manufacturer that lists airflow at 0.1 inches water both in MAEDBS and in the HVI certified products directory. There are fifteen WHFs listed in the HVI directory, and all of these models are rated at a static pressure of 0.1 inches water.

Since the Title 20 appliance efficiency regulations do not specify a static pressure operating point for reporting airflow performance for MAEDBS, it is difficult to be sure whether MAEDBS reports the maximum airflow (at a static pressure of essentially 0.0 inches water), or at one of the other ten operating points determined by the HVI 916 method of test.

WHF TEST PROTOCOL AND TESTING INSTRUMENTS.

Recent field research was conducted to ascertain the reliability of field verification testing of WHF airflow rate (cfm) and fan energy (watt) using three different measurement methods:

- Fan Flowmeter (blower door) using a pressure matching technique.
- Powered Flow Capture Hood
- Traditional Flow Capture Hood

A summary of the results of this field study are given in Appendix D. Field testing showed agreement between the three methods within the measurement error of the devices. All three of these techniques are recommended for use for measuring WHF airflow rates for demonstrating compliance with the performance compliance approach, as long as the airflow rate of the WHF undergoing testing is within the instrument manufacturer's allowable airflow measurement range.

STAFF CONCLUSIONS AND RECOMMENDATIONS

Staff concluded that since the Title 20 appliance efficiency regulations do not specify certification of tested WHF performance at static pressures similar to that of installed WHF units operated in the field, it is likely that many installed WHFs that used the airflow rates published in MAEDBS to demonstrate compliance with the prescriptive requirements in Section 150.1(c)12 are not providing the airflow rate expected for compliance. It is not clear what percentage of the WHF performance data in MAEDBS represent operation of WHFs at the maximum airflow point (essentially 0.0 inch water static pressure), but any WHFs that certified performance to MAEDBS at 0.0 inch water static pressure are probably operating in the field at lower airflow rates than those listed in MAEDBS.

The ventilation cooling effect expected for compliance with the Standards is only attained if the airflow rate specified for compliance by the Standards is attained by the installed WHF. Thus staff has proposed for the 2019 update to the Standards, a performance compliance path based on the proposed WHF airflow rate (cfm) and fan efficacy (w/cfm), and whether or not the installed WHF performance is confirmed by field verification and diagnostic testing. If field verification and diagnostic testing is not performed, a degradation factor will be applied to both the standard design and the proposed design. If field verification and diagnostic testing is performed, a credit will be applied to the performance compliance calculation in proportion to the values proposed for the WHF airflow rate and fan efficacy. Higher proposed values for airflow rate, and lower proposed values for fan efficacy will increase the calculated performance credit, but in order for the WHF to comply, the installed system must demonstrate the WHF performs as proposed as confirmed by field verification and diagnostic testing.

No change to the prescriptive WHF compliance requirement has been proposed, thus compliance with the prescriptive WHF requirements would remain as specified in Standards Section 150.1(c)12 which does not require field verification and diagnostic testing for compliance, and relies solely on verification that the WHF performance listed in the Title 20 MAEDBS complies with the airflow rate specified in Section 150.1(c)12.

Staff recommends use of any of the three WHF field measurement techniques that are described in Appendix D be allowed for use with the HERS field verification diagnostic protocol proposed to be added to the 2019 Title 24 Part 6 Residential Appendix RA3.9 on the condition that the airflow rate of the WHF undergoing testing is within the instrument manufacturer's allowable airflow measurement range.

Staff recommends adding new information in the Residential Compliance Manual that will provide guidance for sizing WHFs based on the consumer's expected attic static pressures during operation of the installed WHF.

APPENDIX A:

WHF FIELD TESTING

Field test data collected from a sample of installed whole house fans.
Data collected August 9, 2015.

	House 1			House 2	
Fan Manufacturer					
Fan Model		(ducted, two fan, WHF)			
Fan Speed	Low (West Fan)	Low (East Fan)	High (Both Fans)	High (normal windows)	High (patio door open)
Published Air Flow	2,860 CFM	2,860 CFM	5,412 CFM	1,414 CFM	1,414 CFM
Measured Whole House Fan (WHF) Air Flow	1,319 CFM	1,278 CFM	2,761 CFM	1,269 CFM	1,269 CFM
% of Published Air Flow	46%	45%	51%	90%	90%
Published Watt Draw	179 Watts	179 Watts	358 Watts	298 Watts	298 Watts
Measured Watt Draw	not measured	not measured	not measured	275 Watts	275 Watts
WHF Operating Attic Pressure (positive pressure WRT outside)	1.5 Pa	2.1 Pa	3.2 Pa	2.3 Pa	2.7 Pa
WHF Operating House Pressure (negative pressure WRT outside)	1.1 Pa	1.2 Pa	2.8 Pa	1.5 Pa	0.3 Pa
Window Area Open (sq.ft.)	16 sq.ft.	16 sq.ft.	16 sq.ft.	11 sq.ft.	31 sq.ft.
House CFA (sq.ft.)	2700 sq.ft.	2700 sq.ft.	2700 sq.ft.	1,214 sq.ft.	1,214 sq.ft.
Average Ceiling Height (ft.)	8.5 feet	8.5 feet	8.5 feet	8 feet	8 feet
WHF Air Flow (CFM/sq.ft.)	0.49 CFM/sq.ft.	0.47 CFM/sq.ft.	1 CFM/sq.ft.	1 CFM/sq.ft.	1 CFM/sq.ft.
WHF Air Flow (ACH)	3.4	3.3	7.2	7.8	7.8
Shell Tighness (CFM50)	2,184 CFM50			not measured	
Shell Tighness (ACH)	5.7 ACH			not measured	
Measured Air Flow (using Plenum Pressure Matching, CFM)				1,175 CFM	1,201 CFM
Static Pressure Behind Grille (negative, Pascals)					
Static Pressure Behind Dampers (negative, Pascals)					
Static Pressure at Fan inlet (negative, Pascals)					

	House 3			House 4			House 5
Fan Manufacturer				Unknown			
Fan Model				Conventional 30 inch, 5,000 CFM fan			Unknown, 4 fans, owner thinks 1,100 CFM each
Fan Speed	Low	Medium	High	Low (normal windows	High (normal windows)	High (more windows open)	All 4 Fans On
Published Air Flow	2,058 CFM	3,092 CFM	4,557 CFM	unknown	unknown	unknown	4,400 CFM (owners memory)
Measured Whole House Fan (WHF) Air Flow	961 CFM	1,594 CFM	1,918 CFM	4,237 CFM	4,410 CFM	4,542 CFM	2,012 CFM
% of Published Air Flow	47%	52%	42%	n/a	n/a	n/a	46%
Published Watt Draw	59 Watts	179 Watts	496 Watts	unknown	unknown	unknown	unknown
Measured Watt Draw	70 Watts	250 Watts	510 Watts	350 Watts	430 Watts	430 Watts	530 Watts
WHF Operating Attic Pressure (positive pressure WRT outside)	0.2 Pa	1.8 Pa	2.5 Pa	3.8 Pa	4.2 Pa	5.7 Pa	7.4 Pa
WHF Operating House Pressure (negative pressure WRT outside)	0.2 Pa	2.4 Pa	3.5 Pa	14.1 Pa	16.7 Pa	5.8 Pa	0 Pa
Window Area Open (sq.ft.)	6.8 sq.ft.	6.8 sq.ft.	6.8 sq.ft.	5.4 sq.ft.	5.4 sq.ft.	12.9 sq.ft.	40 sq.ft.
House CFA (sq.ft.)	1,830 sq.ft.	1,830 sq.ft.	1,830 sq.ft.	1,850 sq.ft.	1,850 sq.ft.	1,850 Sq.ft.	2,500 sq.ft.
Average Ceiling Height (ft.)	8 feet	8 feet	8 feet	9 feet	9 feet	9 feet	10 feet
WHF Air Flow (CFM/sq.ft.)	0.53 CFM/sq.ft	0.87 CFM/sq.ft.	1 CFM/sq.ft.	2.3 CFM/sq.ft	2.4 CFM/sq.ft.	2.5 CFM/sq.ft.	0.8 CFM/sq.ft.
WHF Air Flow (ACH)	3.9	6.5	7.9	15.3	15.9	16.4	4.8
Shell Tighness (CFM50)	not measured			not measured			not measured
Shell Tighness (ACH)	not measured			not measured			not measured
Measured Air Flow (using Plenum Pressure Matching, CFM)	not measured			not measured			not measured
Static Pressure Behind Grille (negative, Pascals)	0.5 Pa	20.7 Pa	30.8 Pa				
Static Pressure Behind Dampers (negative, Pascals)	37.8 Pa	52.1 Pa	73.9 Pa				
Static Pressure at Fan inlet (negative, Pascals)	53.8 Pa	126.0 Pa	198.9 Pa				

APPENDIX B:

CALIFORNIA STATE UNIVERSITY, SACRAMENTO (CSUS): WHF HVI-916 TESTING

CSUS whole house fan laboratory fan efficacy data collected for two whole house fans using the HVI-916 test method.

Test Report Summary Page

Date: January 28, 2016

Appliance Category: Whole House Fans

Manufacturer Name: [redacted]

Brand Name: [redacted]

Model number: [redacted]

Size/Capacity: Fan Duct Diameter 16 ½ inches
Air flow: 2560 CFM High / 1637 CFM Low
Power Consumption: High 120 Watts / Low 64 Watts | 21.3 CFM/Watt

Test Date: January 21, 2016

Complies with Energy Efficiency Standards: N/A

Complies with Design Standards: N/A

Complies with Marking Provisions: Yes

Test Location: California State University Sacramento
Energy Efficiency Laboratory, Santa Clara Hall 1349
6000 J Street, Sacramento, CA 95819

Tested by:

Reviewed by:

1. Summary of Test Procedures

The California Energy Commission's 2015 Appliance Energy Regulations (CEC-400-2015-021), Section 1604.(d) Table D-1 states that the testing procedures for whole house fans shall be governed by HVI-916, tested with manufacturer supplied louvers in place (2009).

Test setup Number 14 described in HVI 916 was used. All pressures were measured with Omega PX653 pressure transducers. Temperatures were measured with class A resistance temperature detectors (RTDs). Fan speed was measured with a Tachometer UNI-T 5URHO (UT3272). Power input was measured with a Tektronix PA1000 power analyzer.

2. Compliance with Energy Efficiency Standards

The California Energy Commission's 2014 Appliance Energy Regulations (CEC– 400–2014–009–CMF) section 1605.1.(d).4 states that there are no energy efficiency standards for whole house fans. The unit was tested on the higher of the two speed options. Test points 1-3 were obtained with an auxillary fan variable inlet supply while points 4-10 were obtained with a damper on the inlet supply. Table 1 summarizes the results.

Test Point	1 (max flow)	2	3	4	5
Fan Speed (rpm)	1364	1364	1364	1364	1364
Ambient Dry Bulb Temperature (°C)	19.6	18	18.1	19.6	18.5
Relative Humidity (%)	64%	63%	63%	63%	63%
Barometric Pressure (Pa)	101,490	102,472	102,472	102,540	102,540
Power Input (W)	136	143	148	153	156
Velocity Pressure Plane 3 (Pa)	26.7	24.8	22.0	19.3	15.2
Static Presssure (Pa)	1.9	11	20	30	44
Air Density Plane 3 (kg/m3)	1.19	1.22	1.22	1.22	1.22
Air Flow Rate - Corrected (cfm)	1837	1751	1652	1547	1371
Air Flow Efficiency (cfm/watt)	13.5	12.2	11.2	10.1	8.8

Test Point	6	7	8	9	10 (shutoff)
Fan Speed (rpm)	1364	1364	1364	1345	1270
Ambient Dry Bulb Temperature (°C)	18.5	18.5	18.5	18.5	18.5
Relative Humidity (%)	63%	63%	63%	63%	63%
Barometric Pressure (Pa)	102,540	102,540	102,540	102,540	102,540
Power Input (W)	156	157	166	223	212
Velocity Pressure Plane 3 (Pa)	14.7	15.6	8.6	1.7	0.0
Static Presssure (Pa)	43	44	64	117	140
Air Density Plane 3 (kg/m3)	1.22	1.22	1.22	1.22	1.22
Air Flow Rate (cfm)	1350	1391	1030	463	0
Air Flow Efficiency (cfm/watt)	8.7	8.9	6.2	2.1	0.0

Figure 1 shows the effect of static pressure air flow rate.

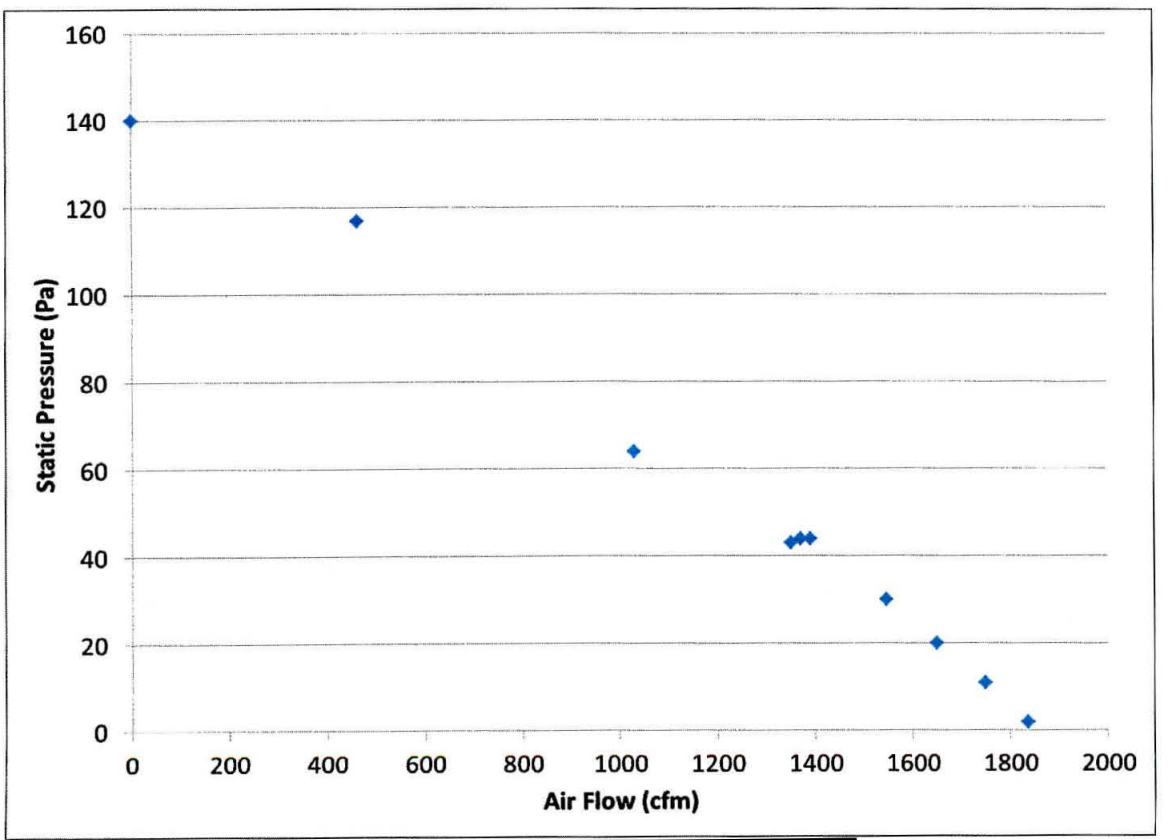


Figure 1. Air flow and static pressure for [redacted]

3. **Compliance with Design Standards**

The California Energy Commission's 2015 Appliance Energy section 1605.3.(w).2 does not list any applicable design standards for whole house fans.

4. **Compliance with Marking Provisions**

As required by the California Energy Commission's 2015 Appliance Energy Regulations section 1607(b), the manufacturer name and model number are clearly marked on the product packaging. The date of manufacture is 03-30-15.

5. Acquisition of Sample

Vendor Name	[redacted]	
Address	[redacted]	
Phone	[redacted]	
Price	**Unit Cost**	$ 783.15
	Tax	$ 62.65
	Shipping	$ 0
	Total	$ 845.80

6. Photographs of Test Setup and Sample

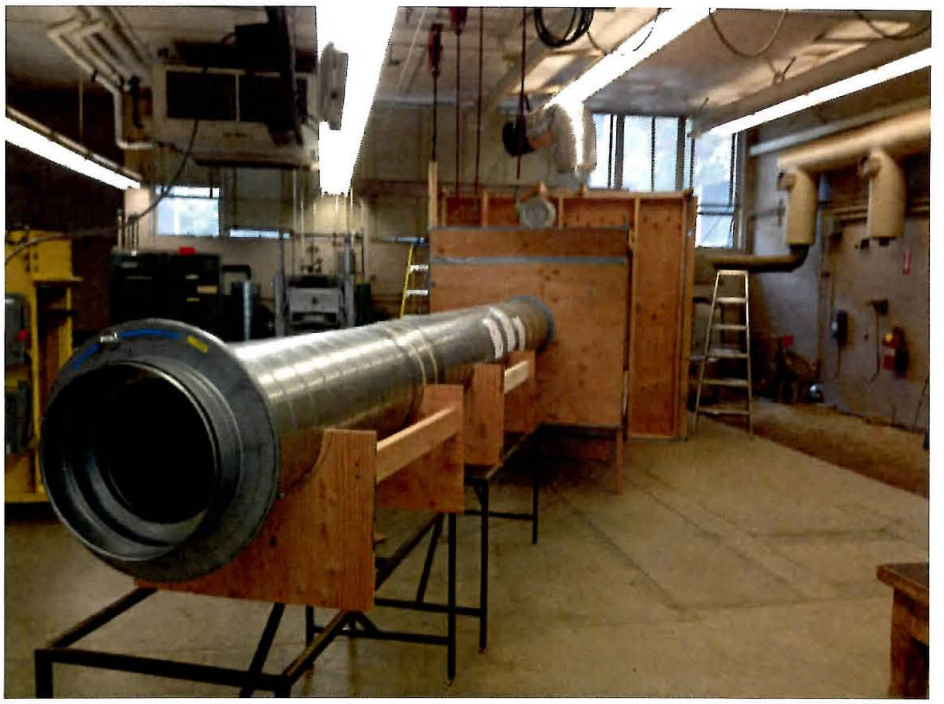


Figure 1 Photograph of the general setup for Whole House Fan Test

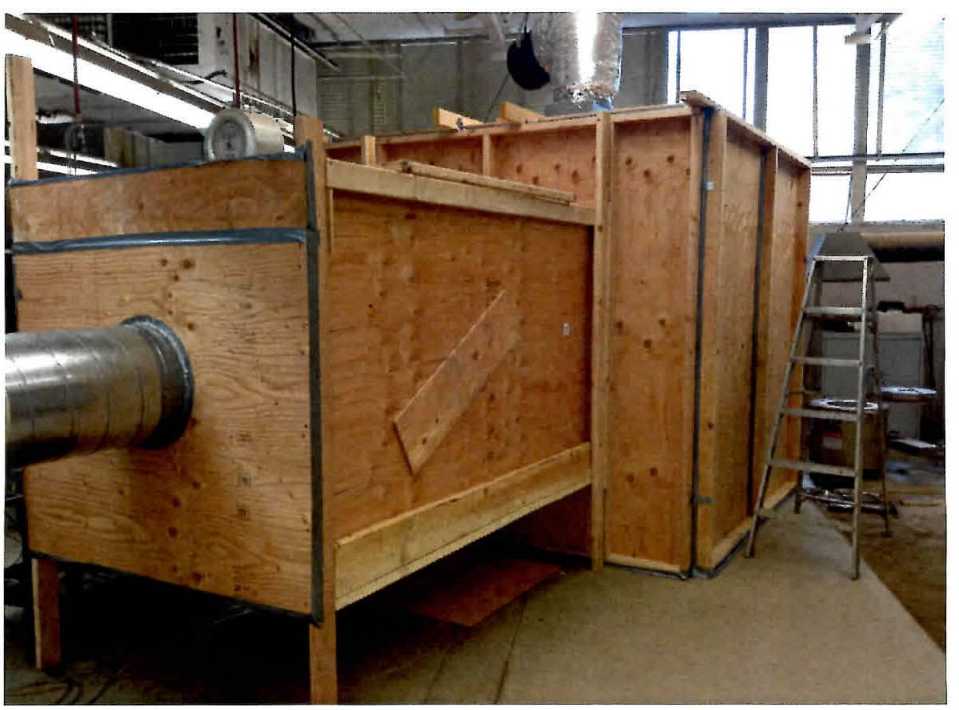


Figure 2 Photograph of the general setup for Whole House Fan Test

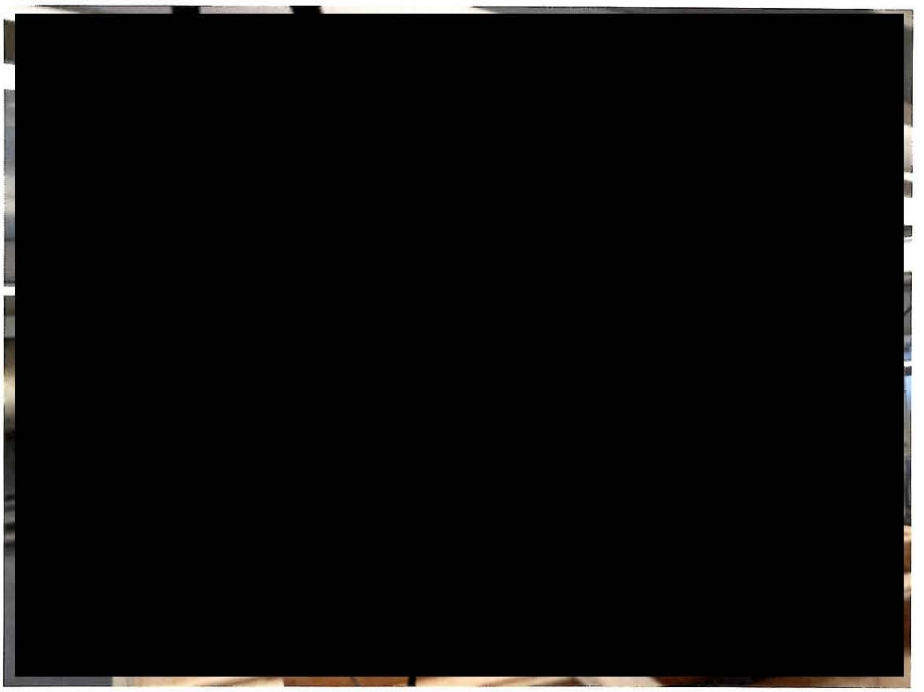


Figure 3 Photograph of the general setup for Whole House Fan Test

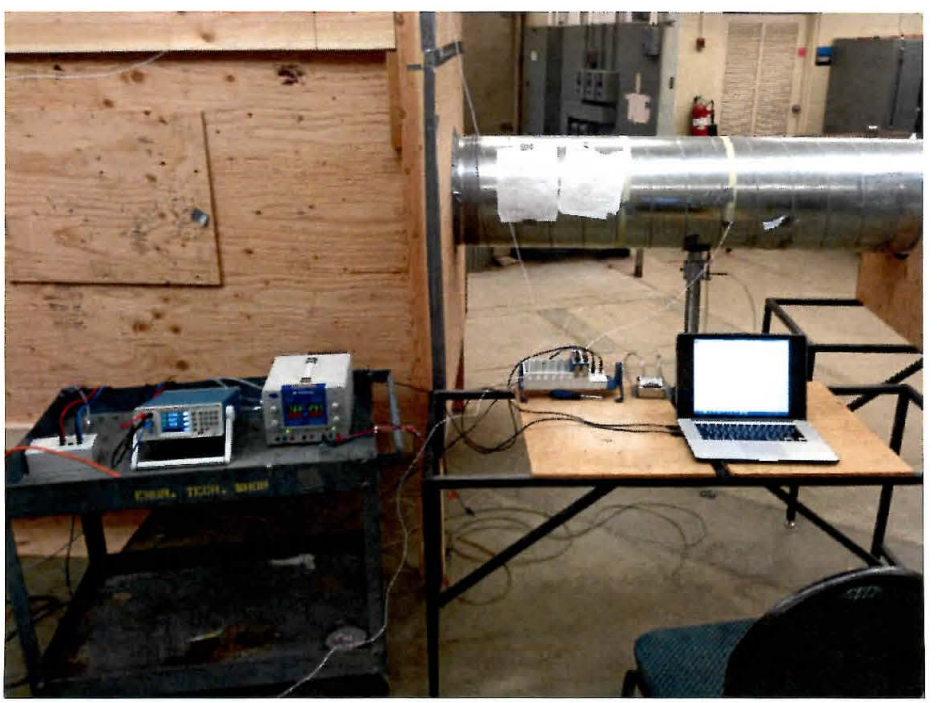


Figure 4 Photograph of the data acquisition instruments. From left to right: Breakout box, Tektronix PA1000 power analyzer, DC Power Supply, National Instruments NI cDAQ - 9182 data acquisition, Omega Differential Pressure transducer, test computer,

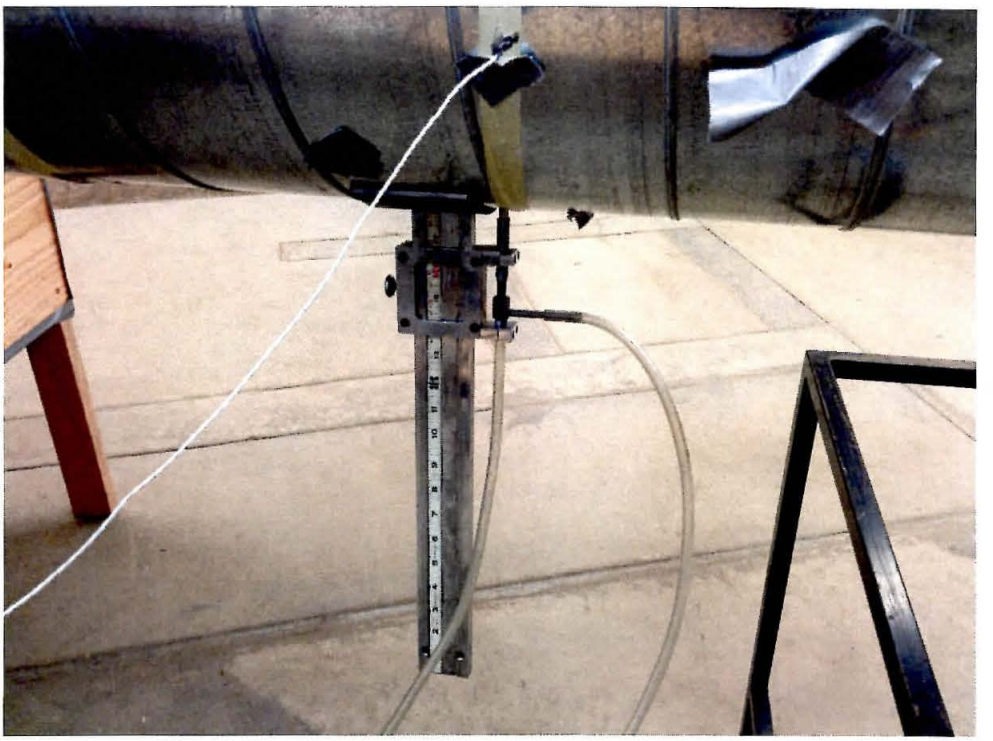


Figure 5 Photograph of the pressure measuring setup – Pitot Tube located in the 16 feet long tube.

Figure 6 Photograph of the RPM measuring device.

Figure 7 Photograph of Quiet Cool STL Pro 2.5 Packing (front and back)

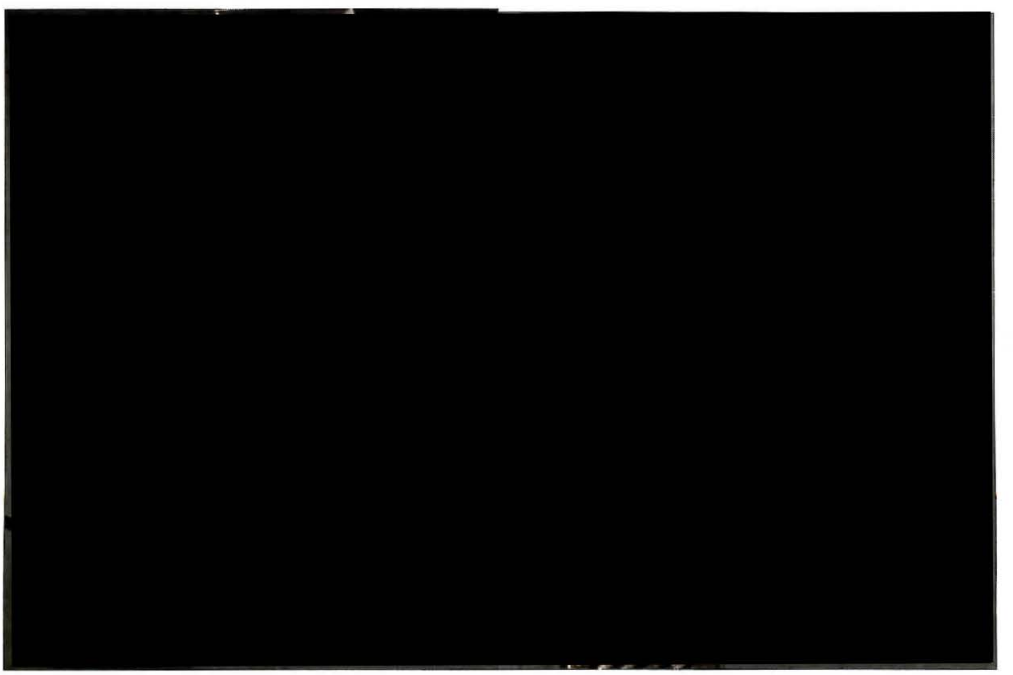


Figure 8 Photograph [redacted] box contents

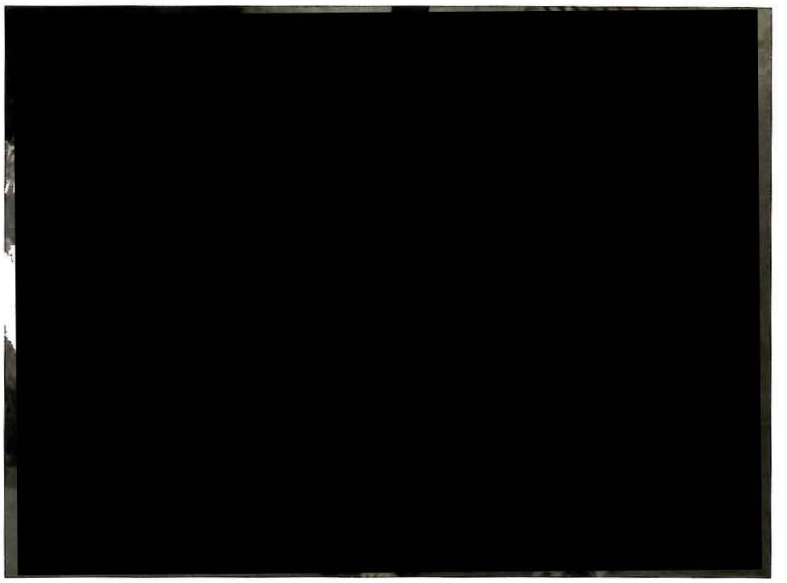


Figure 9 Photograph [redacted] close up of the fan.

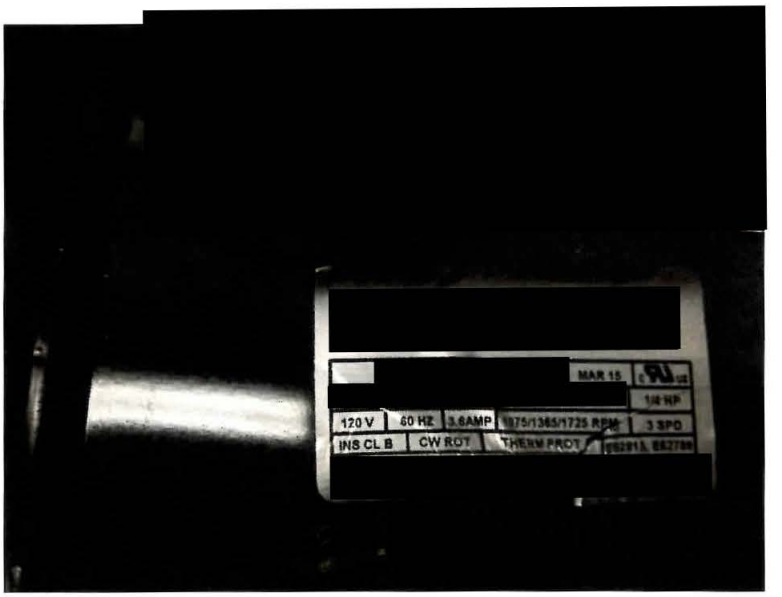


Figure 9 Photograph [redacted] Fan specifications

Test Report Summary Page

Date: February 7, 2016

Appliance Category: Whole House Fans

Manufacturer Name: [redacted]

Brand Name: [redacted]

Model number: [redacted]

Size/Capacity: Fan Duct Diameter 16 ½ inches
Air flow: 2560 CFM High / 1637 CFM Low
Power Consumption: High 120 Watts / Low 64 Watts | 21.3 CFM/Watt

Test Date: January 21, 2016

Complies with Energy Efficiency Standards: N/A

Complies with Design Standards: N/A

Complies with Marking Provisions: Yes

Test Location: California State University Sacramento
Energy Efficiency Laboratory, Santa Clara Hall 1349
6000 J Street, Sacramento, CA 95819

Tested by:

Reviewed by:

1. Summary of Test Procedures

The California Energy Commission's 2015 Appliance Energy Regulations (CEC-400-2015-021), Section 1604.(d) Table D-1 states that the testing procedures for whole house fans shall be governed by HVI-916, tested with manufacturer supplied louvers in place (2009).

Test setup Number 14 described in HVI 916 was used. All pressures were measured with Omega PX653 pressure transducers. Temperatures were measured with class A resistance temperature detectors (RTDs). Fan speed was measured with a Tachometer UNI-T 5URHO (UT3272). Power input was measured with a Tektronix PA1000 power analyzer.

2. Compliance with Energy Efficiency Standards

The California Energy Commission's 2014 Appliance Energy Regulations (CEC– 400–2014–009–CMF) section 1605.1.(d).4 states that there are no energy efficiency standards for whole house fans. The unit was tested on the higher of the two speed options. The unit was tested for maximum flow at approximately zero static pressure and for the maximum static pressure at shutoff.

Test Point	1 (max flow)	2
Fan Speed (rpm)	1364	1280
Ambient Dry Bulb Temperature (^{o}C)	19.6	19.6
Relative Humidity (%)	67%	67%
Barometric Pressure (Pa)	102,336	102,336
Power Input (W)	136	211
Velocity Pressure Plane 3 (Pa)	26.5	0.0
Static Presssure (Pa)	-2.0	132
Air Density Plane 3 (kg/m3)	1.21	1.21
Air Flow Rate - Corrected (cfm)	1818	0
Air Flow Efficiency (cfm/watt)	13.4	0

3. **Compliance with Design Standards**

   The California Energy Commission's 2015 Appliance Energy section 1605.3.(w).2 does not list any applicable design standards for whole house fans.

4. **Compliance with Marking Provisions**

   As required by the California Energy Commission's 2015 Appliance Energy Regulations section 1607(b), the manufacturer name and model number are clearly marked on the product packaging.

5. Acquisition of Sample

Vendor Name	[redacted]	
Address	[redacted]	
Phone	[redacted]	
Price	**Unit Cost**	$ 732.31
	Tax	$ 62.25
	Shipping	$ 0
	Total	$ 794.56

6. Photographs of Unit Under Test

Figure 1. Photograph of [redacted] Packing (front and back)

Figure 2. Photograph [redacted] box contents

Figure 3. Photograph [redacted] close up of the fan.

Figure 4. Photograph [redacted] Fan specifications

Test Report Summary Page

Date: April 22, 2016

Appliance Category: Whole House Fans

Manufacturer Name: [redacted]

Brand Name: [redacted]

Model number: [redacted]

Size/Capacity: Fan Duct Diameter 16 inches
Air flow: 2617 CFM
Power Consumption: 270 watts

Test Date: March 29, 2016 to April 21, 2016

Results Summary: Max Flow: 2552 cfm
Power: 282 watts
Efficiency: 9.05 cfm per watt

Complies with Energy Efficiency Standards: N/A

Complies with Design Standards: N/A

Complies with Marking Provisions: No

Test Location: California State University Sacramento
Energy Efficiency Laboratory, Santa Clara Hall 1349
6000 J Street, Sacramento, CA 95819

Tested by:

Tim Marbach

1. Summary of Test Procedures

The California Energy Commission's 2015 Appliance Energy Regulations (CEC-400-2015-021), Section 1604.(d) Table D-1 states that the testing procedures for whole house fans shall be governed by HVI-916, tested with manufacturer supplied louvers in place (2009).

Test setup Number 14 described in HVI 916 was used. All pressures were measured with Omega PX653 pressure transducers. Temperatures were measured with class A resistance temperature detectors (RTDs). Power input was measured with a Tektronix PA1000 power analyzer.

2. Compliance with Energy Efficiency Standards

The California Energy Commission's 2015 Appliance Energy Regulations (CEC– 400–2015–021–CMF) section 1605.1.(d).4 states that there are no energy efficiency standards for whole house fans.

Test Point	1 (max flow)	2	3	4	5
Ambient Dry Bulb Temperature (°C)	24°C	24°C	24°C	24°C	25°C
Relative Humidity (%)	42%	42%	42%	42%	40%
Barometric Pressure (Pa)	101.5 kPa	101.5 kPa	101.2 kPa	101.2 kPa	101.2 kPa
Power Input (W)	282 W	289 W	295 W	297 W	306 W
Velocity Pressure Plane 3 (Pa)	50.8 Pa	41.5 Pa	37.2 Pa	35.5 Pa	26.6 Pa
Static Presssure (Pa)	1 Pa	11 Pa	21 Pa	29 Pa	47 Pa
Air Density Plane 3 (kg/m3)	1.18 kg/m^3	1.18 kg/m^3	1.18 kg/m^3	1.18 kg/m^3	1.18 kg/m^3
Air Flow Rate - Corrected (cfm)	2552 cfm	2307 cfm	2183 cfm	2129 cfm	1846 cfm
Air Flow Efficiency (cfm/watt)	9.05	7.98	7.40	7.17	6.04

Test Point	6	7	8	9	10 (shutoff)
Ambient Dry Bulb Temperature (°C)	25°C	25°C	25°C	25°C	25°C
Relative Humidity (%)	40%	40%	40%	40%	40%
Barometric Pressure (Pa)	101.4 kPa	101.4 kPa	101.4 kPa	101.4 kPa	101.4 kPa
Power Input (W)	311 W	322 W	330 W	336 W	341 W
Velocity Pressure Plane 3 (Pa)	21.8 Pa	13.7 Pa	6.3 Pa	1.8 Pa	0.0 Pa
Static Presssure (Pa)	62 Pa	78 Pa	96 Pa	105 Pa	120 Pa
Air Density Plane 3 (kg/m3)	1.18 kg/m^3	1.17 kg/m^3	1.17 kg/m^3	1.17 kg/m^3	1.17 kg/m^3
Air Flow Rate (cfm)	1675 cfm	1327 cfm	898 cfm	487 cfm	0 cfm
Air Flow Efficiency (cfm/watt)	5.39	4.12	2.72	1.45	0.00

Figure 1 shows the effect of static pressure air flow rate.

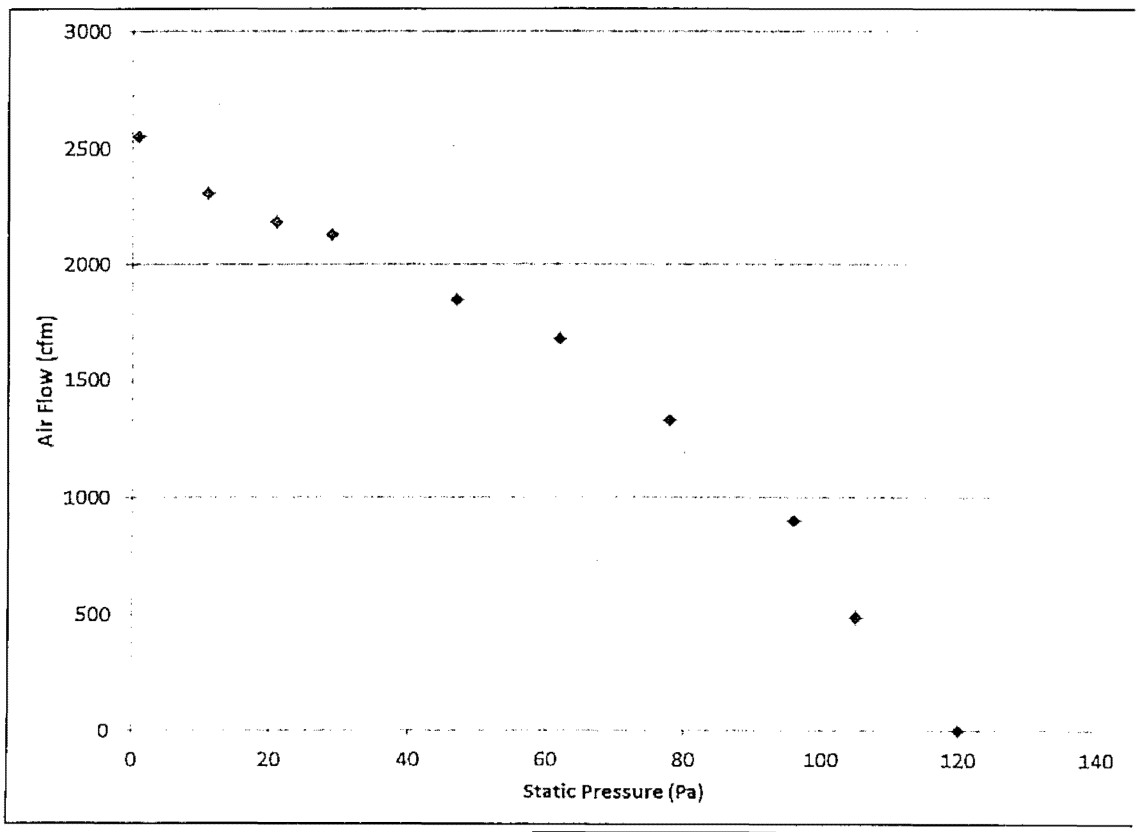


Figure 1. Air flow and static pressure for [redacted]

3. **Compliance with Design Standards**

The California Energy Commission's 2015 Appliance Energy section 1605.3.(w).2 does not list any applicable design standards for whole house fans.

4. **Compliance with Marking Provisions**

As required by the California Energy Commission's 2015 Appliance Energy Regulations section 1607(b), the manufacturer name and model number of the fan are not marked on the unit. The motor model number and manufacture date are printed on the unit, as seen in Figure 4.

5. Acquisition of Sample

Vendor Name	[redacted]	
Address	[redacted]	
Phone	[redacted]	
Price	**Unit Cost**	$ 1195.00
	Tax	$ 89.63
	Shipping	$ 0
	Total	$ 1284.63

6. Photographs of Test Setup and Sample

Figure 2. Photograph of fan with flexible duct.

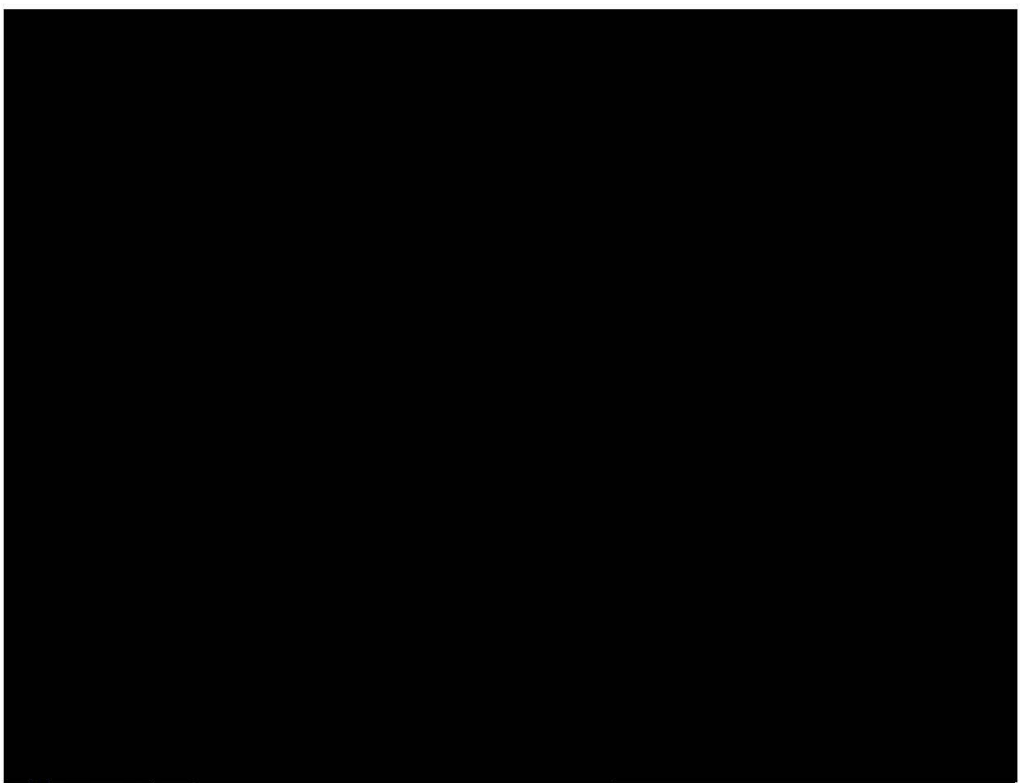


Figure 3. Photograph of

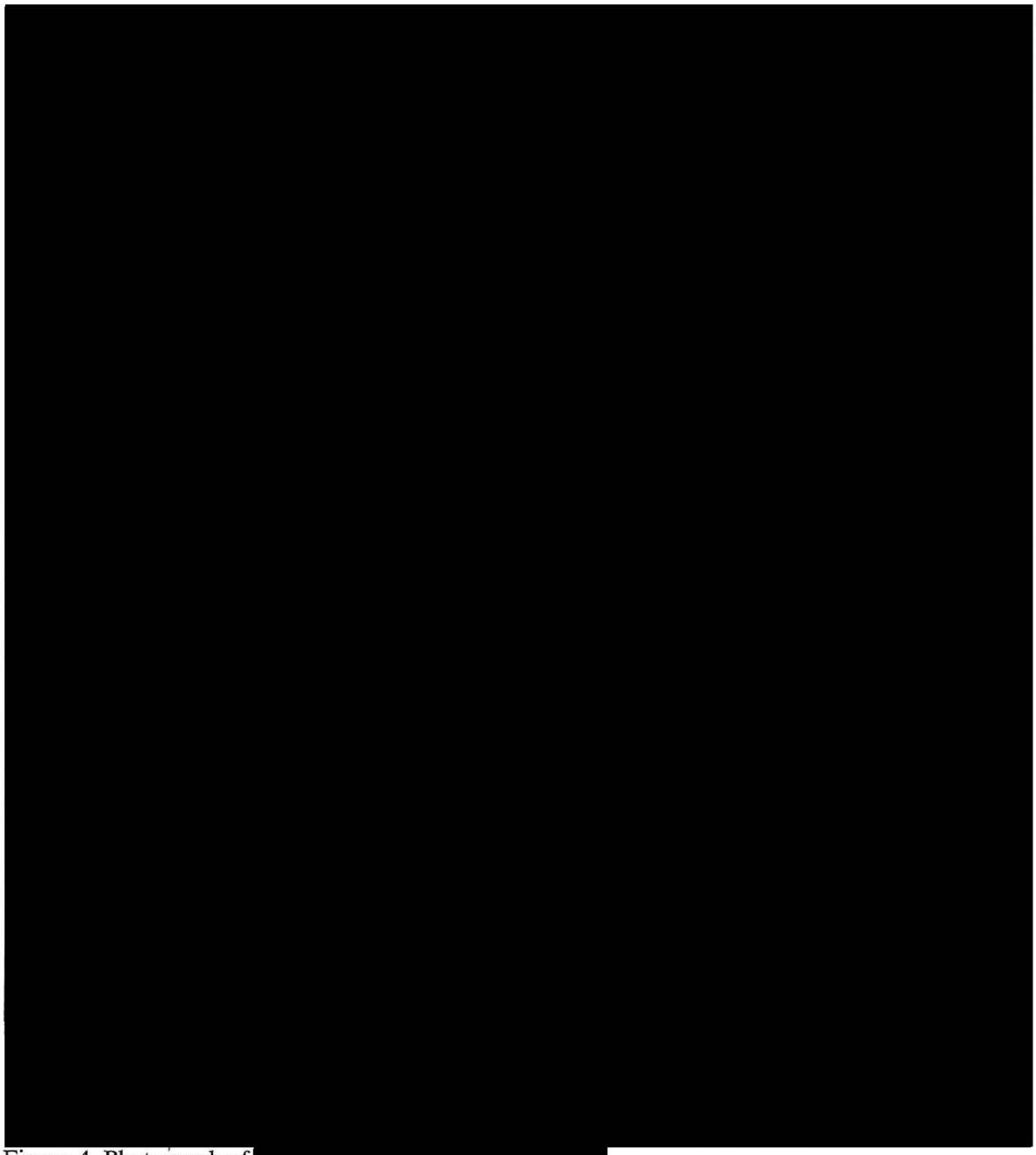


Figure 4. Photograph of [redacted]

APPENDIX C:

BR LABORATORIES, INC.: WHF HVI-916 TESTING

BR Laboratories, Inc. whole house fan efficacy data collected for one of the two whole house fans tested by CSUS.

BR LABORATORIES, INC.
P.O. Box 1249
Huntington Beach, CA 92647
(714) 891-0206 • Fax: (714) 893-0818
E-mail: bsbrli@aol.com

ACCREDITED
ISO 17025

REPORT NUMBER: 1604-08
TOTAL PAGES: 17
(Including Title Page and
Table of Contents Page)

TEST REPORT ON

[redacted]

WHOLE HOUSE FAN

MODEL NO. : [redacted]
SERIAL NO. : TEST UNIT

APRIL 15, 2016

TEST PROCEDURE : Test Method HVI-916 (2009), Home Ventilating Institute Airflow Test Procedure

TEST RESULTS :

- [redacted] **whole house fan was tested in accordance with HVI-916 (2009). The results at 0.003 inch (approximately 0.00 inch) water column inlet static pressure corrected to Standard Atmospheric Density are as follows:**

Whole-House Fan Type	**:**	**Direct-drive single fan**
Measured Airflow Rate	**:**	**2,630 CFM**
Measured Fan Motor Power	**:**	**286 watts**
Air Flow Efficiency	**:**	**9.2 CFM/watt**

- **Meets marking requirements of the California Appliance Efficiency Regulations (CAER).**

Sr. Project/Test Engineer

Bodh R. Subherwal, P.E.
Technical Manager

PREPARED FOR : [redacted]

PREPARED BY : BR LABORATORIES, INC.
IAS accredited ANS/ISO/IEC 17025: 2005 Laboratories (TL-427)
EPA approved for ENERGY STAR Testing Laboratory
P.O. Box 1249
Huntington Beach, CA 92647

TABLE OF CONTENTS

I. BACKGROUND

- BR Laboratories was provided and asked to test the [redacted] direct drive whole house single fan model [redacted] in accordance with the test procedure outlined in HVI Publication 916 (2009) HVI® Air Flow Test Procedure (in accordance with ANSI consensus standards for rating airflow of residential ventilating products before HVI Certification).

II. APPLIANCE DATA

1. Appliance nameplate data included the following:

Description	:	Direct drive, whole house fan
Manufacturer	:	[redacted]
Model No.	:	[redacted]
Serial No.	:	TEST UNIT

Manufacturer's Specifications:

Air Flow	:	2,617 CFM @ 0.0" S.P.
Grill Size (Outer)	:	16" × 26"
Nominal Outlet	:	16 in diameter
Control	:	Two (2) speed
Electrical	:	120 V, 60 Hz
Energy Use	:	270 watts
Efficiency	:	8.5 CFM/watt (max)
Unit Weight	:	48 lbs
Markings	:	15 YR Limited fan motor warranty

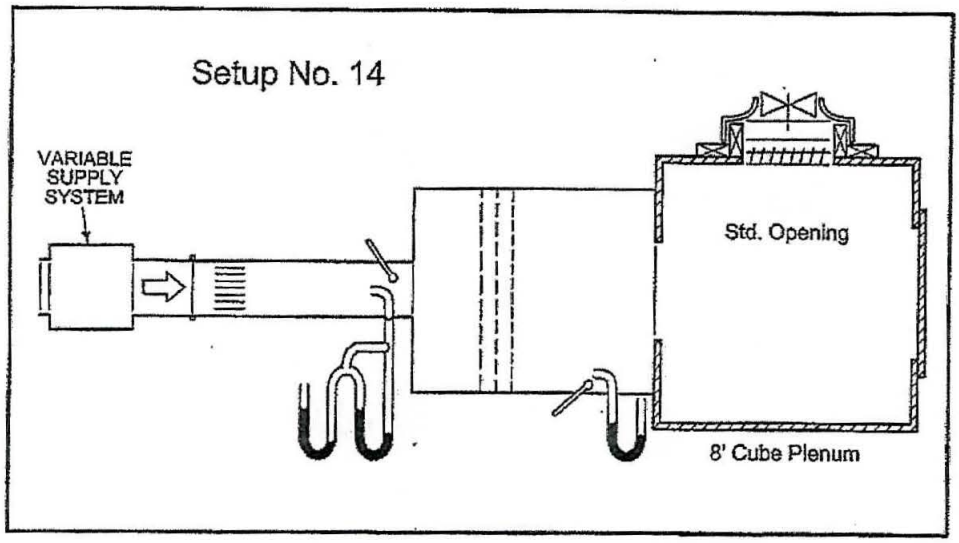
Equipped with a brushless damper

2. [redacted] direct drive whole house single fan model [redacted] carried manufacturer's name and address along with model no., serial no.: TEST UNIT on the package/crate and on the whole house fan nameplate (permanently and legibly marked). The contact person at [redacted] with phone no.: [redacted]

III. TEST METHOD (Section 6)

- The [redacted] Direct Drive Whole House Fan Model [redacted] was tested in accordance with the test procedure outlined in Test Method HVI-916 (2009).

As required in Section 5 (HVI Product Categories and Their Setups), Whole House Comfort Ventilators are to be tested using Setup No. 14. (See Fig.).



The ducted inlet chamber contained a 16" × 26" grill to make it possible to determine air flow rate at various static pressures. The ventilator (whole house fan) was mounted in the "ceiling" of an 8-ft. cube, plywood plenum.

IV. TEST PROCEDURE (Section 7)

With rated voltage applied, the fan was turned on and measurements were taken at 0.000 in. (0.003 in.) W.C. static pressure, as listed under measured values in Test Results, such as differential pressure, air velocity, fan input power. This procedure was repeated for a total of 10 test points, from 0.003 in. W.C. up to shut off pressure of 0.425 in. W.C., as required in section 7.1.2.

Calculations were then made to determine air flow rate at test conditions, and then corrected to Standard Atmospheric Density, as required in Section 7.1.6, for each test point, allowing a curve of Airflow Rate vs. Static Pressure to be plotted.

Finally, the air flow efficiency was calculated in CFM/watt for each test point.

The fan was tested with supplied inlet grill (16" × 26").

V. TEST DATA AND CALCULATIONS

Manufacturer: [redacted]

Model No: [redacted]

Serial No: (test unit)

Exhaust Fan Type: Whole House Fan, Direct Drive

Rated Airflow (cfm): 2617

			TEST POINTS				
Measured Values		units	**1 Shut Off Pressure**	**2**	**3**	**4**	**5**
Diameter of test duct, in.	D	in	16	16	16	16	16
Diameter of test duct, ft.		ft.	1.3	1.3	1.3	1.3	1.3
Area of test duct	A	ft^2	1.396	1.396	1.396	1.3963	1.3963
Barometric pressure	p_b	in Hg	30.12	30.12	30.12	30.12	30.12
Dry-bulb temp.	t_d	°F	67.5	67.6	67.8	67.9	68.0
Relative humidity		%	52.4	53.1	53.2	53.0	51.6
Wet-bulb temp.		°F	56.9	57.1	57.3	57.4	57.1
Static pressure		in. WC	0.425	0.378	0.335	0.262	0.217
Velocity pressure	P_{v3}	in. WC	0.0000	0.0050	0.0215	0.0469	0.0672
Dry-bulb temp., meas. plane	t_{d3}	°F	67.4	67.5	67.6	67.8	67.8
Fan input, true RMS watts		watts	365	355	347	335	327

Calculations

Saturated vapor pressure	p_e	in Hg	0.4636	0.4672	0.4708	0.4726	0.4672
Partial vapor pressure	p_p	in Hg	0.3454	0.3501	0.3537	0.3555	0.3456
Atmospheric air density	ρ_0	lbm/ft^3	0.07542	0.07540	0.07537	0.07535	0.07535
Air density at meas. plane 3	ρ_3	lbm/ft^3	0.07551	0.07549	0.07546	0.07542	0.07542
Air Velocity for test duct	V_3	fpm	0	282	586	865	1036
Airflow rate for test duct	Q_3	cfm	0	394	818	1208	1446
Fan airflow rate at test condition	Q	cfm	0	395	819	1209	1447

Standard air density	ρ_c	lb/ft^3	0.075	0.075	0.075	0.075	0.075
Fan airflow rate	**Q**	cfm	0	395	819	1209	1447
Fan Motor Power, standard condition	$\mathbf{W_c}$	watts	363	353	345	333	325

Air Flow Efficiency		cfm/watt	**0.00**	**1.12**	**2.37**	**3.63**	**4.45**

V. TEST DATA AND CALCULATIONS (cont'd)

Manufacturer: [redacted]

Model No: [redacted]

Serial No: (test unit)

Exhaust Fan Type: Whole House Fan, Direct Drive

Rated Airflow (cfm): 2617

Measured Values		units	TEST POINTS 6	7	8	9	10 Max Flow Rating
Diameter of test duct, in.	D	in	16	16	16	16	16
Diameter of test duct, ft.		ft.	1.3	1.3	1.3	1.3	1.3
Area of test duct	A	ft^2	1.3963	1.3963	1.3963	1.3963	1.3963
Barometric pressure	p_b	in Hg	30.12	30.13	30.12	30.12	30.12
Dry-bulb temp.	t_d	°F	68.2	68.2	68.4	68.6	68.9
Relative humidity		%	51.4	51.6	51.7	51.3	51.0
Wet-bulb temp.		°F	57.2	57.3	57.3	57.5	57.7
Static pressure		in. WC	0.162	0.127	0.082	0.039	0.003
Velocity pressure	P_{v3}	in. WC	0.0864	0.1200	0.1510	0.1936	0.2217
Dry-bulb temp., meas. plane	t_{d3}	°F	68	68.1	68.2	68.4	68.8
Fan input, true RMS watts		watts	320	316	306	298	287

Calculations

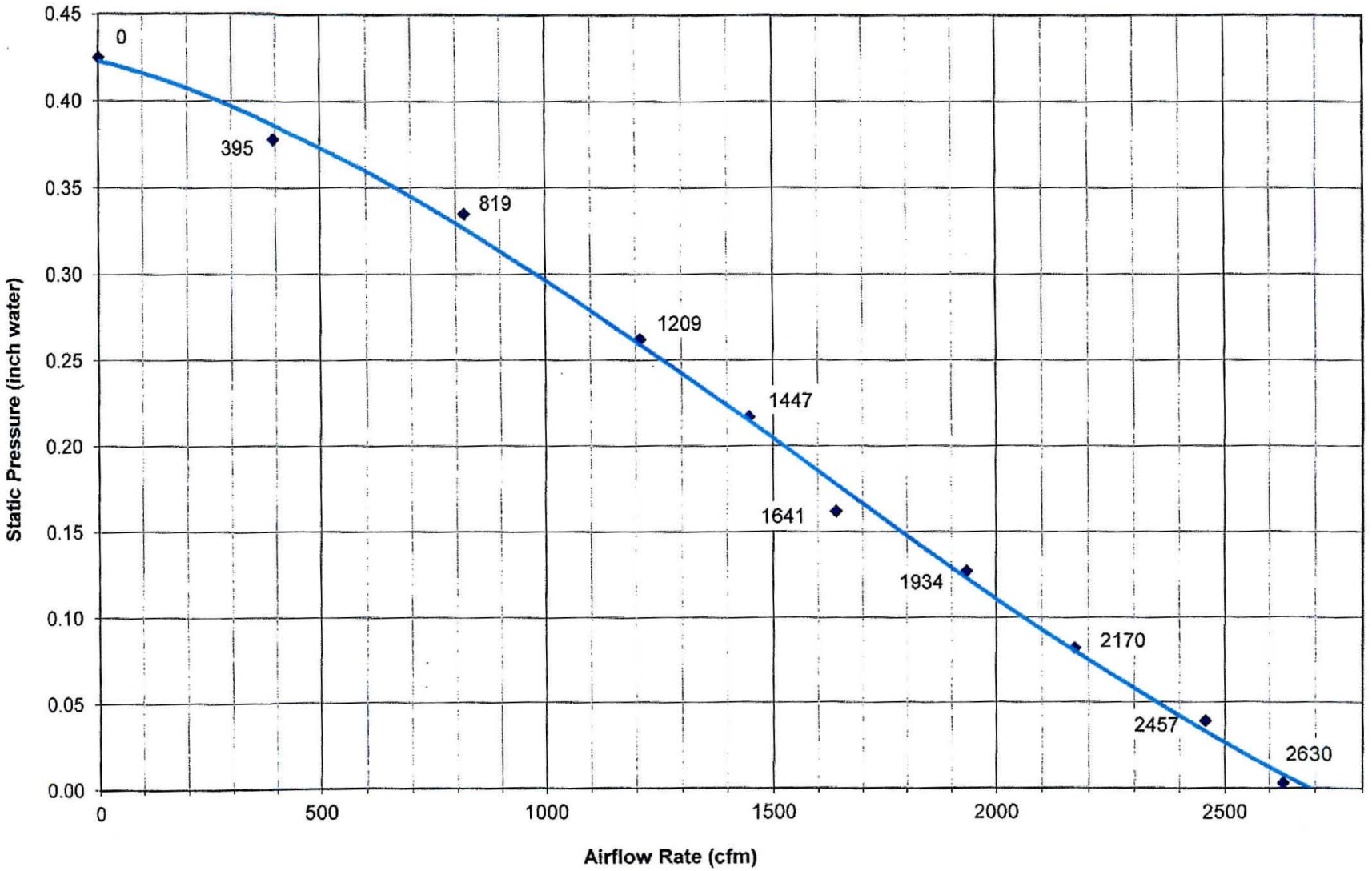
Saturated vapor pressure	p_e	in Hg	0.4690	0.4708	0.4708	0.4744	0.4780
Partial vapor pressure	p_p	in Hg	0.3463	0.3491	0.3470	0.3506	0.3531
Atmospheric air density	ρ_0	lbm/ft^3	0.07532	0.07534	0.07529	0.07526	0.07521
Air density at meas. plane 3	ρ_3	lbm/ft^3	0.07538	0.07538	0.07533	0.07529	0.07523
Air Velocity for test duct	V_3	fpm	1174	1384	1553	1759	1883
Airflow rate for test duct	Q_3	cfm	1640	1933	2169	2456	2629
Fan airflow rate at test condition	Q	cfm	1641	1934	2170	2457	2630

Standard air density	ρ_c	lb/ft^3	0.075	0.075	0.075	0.075	0.075
Fan airflow rate	**Q**	cfm	1641	1934	2170	2457	2630
Fan Motor Power, standard condition	$\mathbf{W_c}$	watts	319	315	305	297	286

Air Flow Efficiency		cfm/watt	**5.15**	**6.15**	**7.12**	**8.27**	**9.19**

[redacted]

Static Pressure vs. Airflow
Fan Speed Setting: High (Maximum)



SAMPLE CALCULATIONS

(Test Point 10, 0.003 "w.c. Static Pressure)

5.1.5 Atmospheric air density

Saturated vapor pressure, p_e

$$p_e = (2.96 \times 10^{-4})t_w^2 - (1.59 \times 10^{-2})t_w + 0.41$$

$$p_e = (2.96 \times 10^{-4})(57.7\ ^\circ\text{F})^2 - (1.59 \times 10^{-2})\,)(57.7\ ^\circ\text{F}) + 0.41$$

$$= 0.4780\ \textit{inches Hg}$$

Partial vapor pressure, p_p

$$p_p = p_e - p_b\left(\frac{t_d - t_w}{2700}\right)$$

$$p_p = 0.4780\ \textit{inches Hg} - 30.12\ \textit{inches Hg}\left(\frac{68.9^\circ\text{F} - 57.7^\circ\text{F}}{2700}\right)$$

$$p_p = 0.3531\ \textit{inches Hg}$$

Atmospheric air density, ρ_0

$$\rho_0 = \frac{70.73(p_b - 0.378p_p)}{R(t_d + 459.67)};\ \text{R} = 53.35\ \frac{\text{ft}\bullet\text{lb}}{\text{lbm}\bullet^\circ R}\ \text{(gas constant)}$$

$$\rho_0 = \frac{70.73(30.12\ \textit{inches Hg} - 0.378(3531\ \textit{inches Hg}))}{53.35(68.9^\circ\text{F} + 459.67)}$$

$$\rho_0 = 0.07521\ \textit{lbm/ft}^3$$

SAMPLE CALCULATIONS (cont'd)
(Test Point 10, 0.003 "w.c. Static Pressure)

5.1.6 Air density at plane 3, ρ_3

$$\rho_3 = \rho_0\left(\frac{t_d + 459.7}{t_{d5} + 459.7}\right)\left(\frac{P_s + 13.63 p_b}{13.63 p_b}\right)$$

$$\rho_3 = 0.07521\frac{lbm}{ft^3}\left(\frac{68.9°\,\mathrm{F} + 459.7}{68.8°\,\mathrm{F} + 459.7}\right)\left(\frac{0.003"w.c + 13.63(30.12"Hg)}{13.63(30.12"Hg)}\right)$$

$$\rho_3 = 0.07523\ lbm/ft^3$$

Air velocity for test duct, V_3

$$V_3 = 1097\sqrt{\frac{P_{v3}}{\rho_3}}$$

$$= 1097\sqrt{\frac{0.2217\,\mathrm{in.\,WC}}{0.07523\,\mathrm{lbm/ft^3}}}$$

$$= 1883\ \mathrm{fpm}$$

5.2 Fan flow rate at test conditions

Airflow rate for test duct, Q_3

$$Q_3 = V_3 A_3$$

$$= (1883\ \mathrm{fpm})(1.3963\ ft^3)$$

$$= 2629\ \mathrm{cfm}$$

SAMPLE CALCULATIONS (cont'd)
(Test Point 10, 0.003 "w.c. Static Pressure)

5.2.7 Fan airflow rate at test conditions, Q

$$Q = Q_3\left(\rho_3 / \rho_0\right)$$

$$= 2629 cfm\left(0.07523 \frac{lbm}{ft^3} \Big/ 0.07521 \frac{lbm}{ft^3}\right)$$

$$= 2630 \text{ cfm}$$

5.4.1 Fan Motor Watts at standard atmospheric density

$$\text{Watts}_c = \text{Watts}\left(\frac{\rho_c}{\rho_0}\right)$$

$$= 287 \text{ watts}\left(\frac{0.075 \frac{lbm}{ft^3}}{0.07521 \frac{lbm}{ft^3}}\right)$$

$$= 286 \text{ watts}$$

5.4.3 Airflow Efficiency

$$\frac{Q}{Watts_c} = \frac{2630\, cfm}{286\, watts}$$

$$= 9.19\ cfm/watt$$

VI. SUMMARY OF TEST RESULTS

- Appliance : Whole House Fan (Direct Drive)
- Manufacturer : [redacted]
- Model No. : [redacted]
- Serial No. : TEST UNIT
- Whole-House Fan Type : Direct Drive Single Fan
- Measured Air Flow Rate : 2,630 CFM @ 0.0" S.P. (= 0.003" S.P.)
- Fan Input, Power : 286 W
- Air Flow Efficiency : 9.2 CFM/WATT (@ 0.0" S.P.)
- Met the marking requirements of the California Appliance Efficiency Regulations (CAER).

VII. INSTRUMENTATION/EQUIPMENT USED

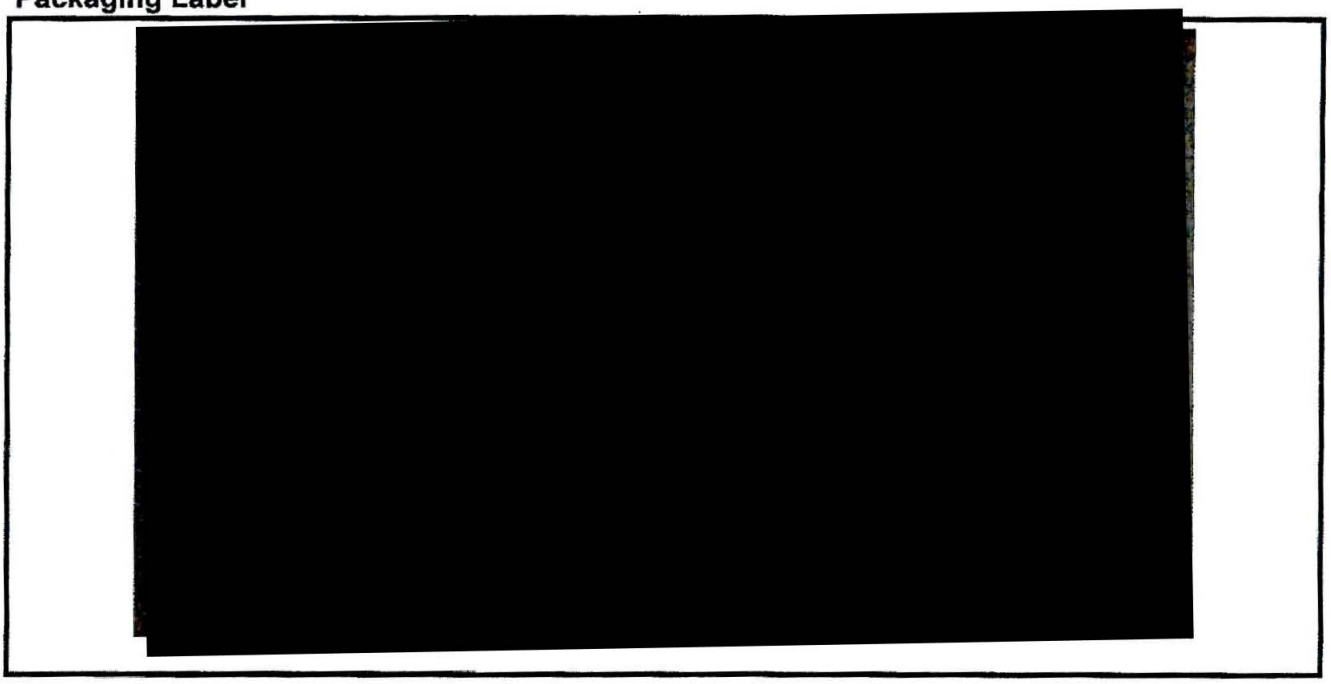
Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
Datalogger	Campbell Scientific	21x	11148	05-Feb-2016	05-Feb-2017
Measurement Rule	Starett	TX1-25	15308036	17-Aug-2015	17-Aug-2017
Pressure Transducer	Dwyer	MS-711-LCD	E05Y040053	05-Oct-2015	05-Oct-2016
Pressure Transducer	Dwyer	MS-721-LCD	E09X020181	05-Oct-2015	05-Oct-2016
Relative Humidity/ Temperature Probes	Omega	RH20F	200-99-01193	05-Oct-2015	05-Oct-2015
Watt Meter	Yokogawa	CW240	T1K5017	19-Mar-2015	19-Mar-2016

Date of Test : April 13, 2016

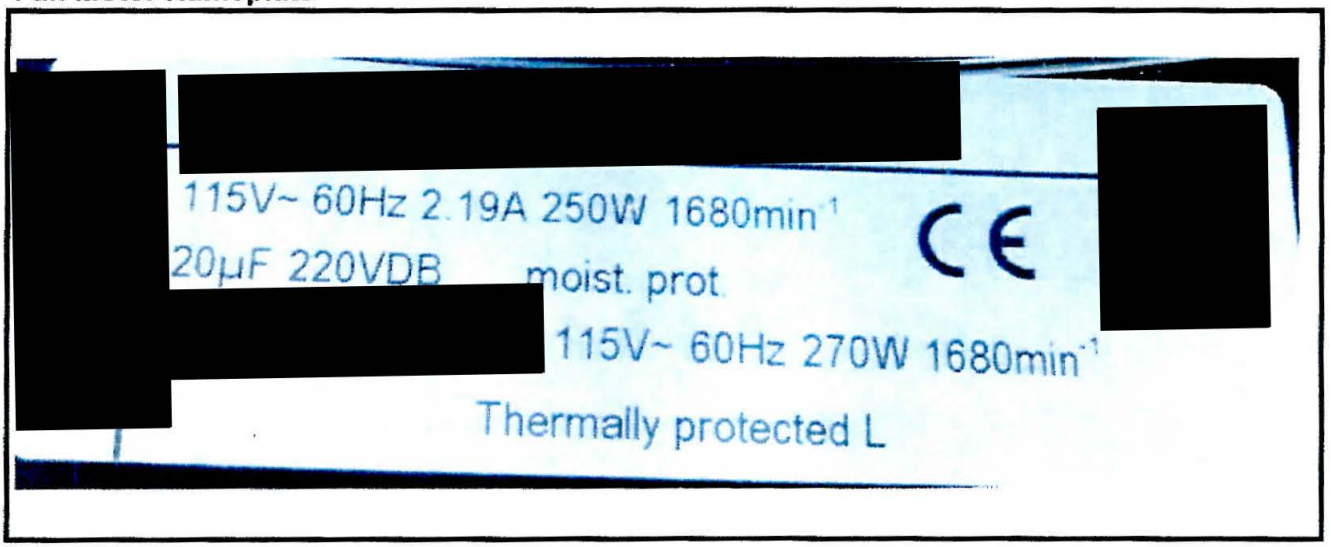
APPENDIX

- NAMEPLATE
- TEST UNIT

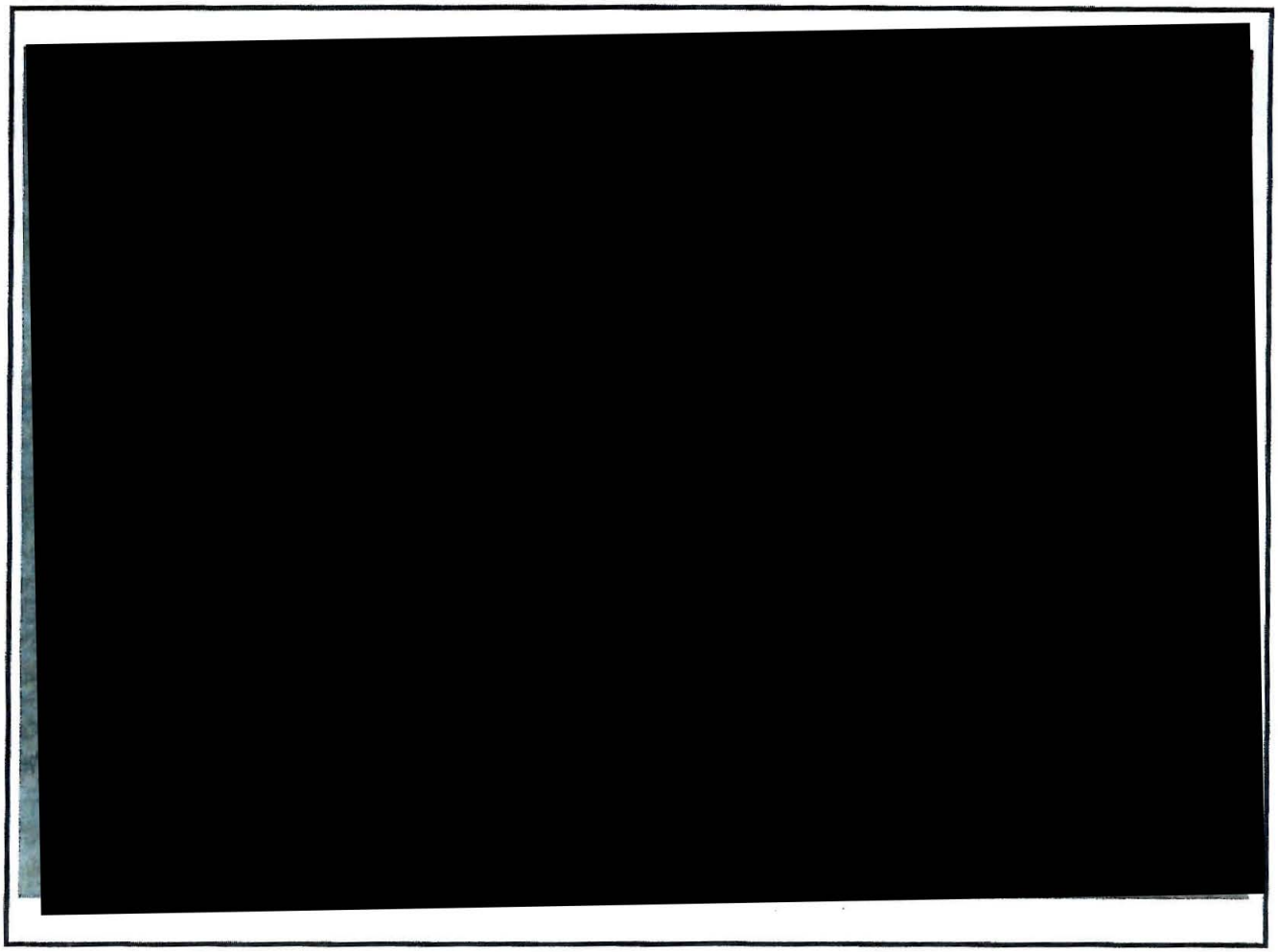
Packaging Label



Fan Motor Nameplate



Test Unit



APPENDIX D:

WHF FIELD TESTING COMPARISON OF THREE AIRFLOW MEASUREMENT METHODS

Measurements taken by: Rick Chitwood and Russ King

Field test dates: August 31st and September 1st, 2017

Field testing was performed on installed whole house fans and data was compared between three methods of airflow measurement (fan flowmeter (blower door), powered flow capture hood, traditional flow capture hood).

Whole House Fan (WHF) Airflow Measurement Summary

Measurements taken by: Rick Chitwood and Russ King

Field test dates: August 31st and September 1st, 2017

House 1: [redacted], two small WHF's, all three test methods compared

	House Pressure (Pascals)	Total WHF Airflow (CFM)	Total WHF Watt Draw (Watts)	Watts per CFM (Watts/CFM)	Airflow per sq. ft. (CFM/sq. ft.)
Capture Hood	-7.5	1,310	148	0.11	1.5
Blower Door	-7.5	1,460	148	0.10	1.7
Powered Capture Hood	-7.5	1,662	148	0.09	2.0

Our first test house. It wasn't until the second house that we figured out that when using the automatic mode (letting the meter auto-adjust the fan to a target pressure) the powered capture hood was pushing open the dampers on these WHF's wider than normal operation – which accounts for the higher flows.

House 2: [redacted], three small WHF's, all three test methods compared

	House Pressure (Pascals)	Total WHF Airflow (CFM)	Total WHF Watt Draw (Watts)	Watts per CFM (Watts/CFM)	Airflow per sq. ft. (CFM/sq. ft.)
Capture Hood	-8.7	1,775	194	0.11	1.6
Blower Door	-8.7	1,804	194	0.11	1.6
Powered Capture Hood	-8.7	1,859	194	0.10	1.7

On this house, we learned that the powered capture hood gave lower flow rates than the previous house (an in agreement with the other methods) if the capture hood fan was operated manually. The automatic mode runs the capture hood fan above the zero-pressure target which pushes the dampers to a full open position – yielding a higher flow reading. We should have gone back to the first house and remeasured the powered capture hood flows. Considering the published accuracy of the three measurement devices – this is near perfect agreement. Near perfect agreement does not happen often with field measurements.

House 3: [redacted], three small WHF's, WHF system wasn't operational

The WHF system wasn't operational at this Stockton research house. Even if it was operational we would not have been able to make a comparison of the three-measurement systems due to the grille location on one of the fans. The ceiling of the master bedroom was vaulted and the ceiling located WHF grille was at the very top of the vault – too close to the wall to get a capture hood or a powered capture hood over the grille. The only measurement method that would have worked on this house was the blower door method.

House 4: [redacted], large WHF, capture hood could not be used since air flow was over 2,000 CFM

	House Pressure (Pascals)	Total WHF Airflow (CFM)	Total WHF Watt Draw (Watts)	Watts per CFM (Watts/CFM)	Airflow per sq. ft. (CFM/sq. ft.)
Capture Hood					
Blower Door	-6.4	2,777	830	0.30	1.5
Powered Capture Hood	-6.4	2,950	830	0.28	1.6

Excellent agreement between the two methods.

House 5: [redacted] **1**, large old conventional WHF, capture hood could not be used since air flow was over 2,000 CFM, the powered capture hood could not be used without taping over part of the WHF intake grille.

	House Pressure (Pascals)	Total WHF Airflow (CFM)	Total WHF Watt Draw (Watts)	Watts per CFM (Watts/CFM)	Airflow per sq. ft. (CFM/sq. ft.)
Capture Hood					
Blower Door (grille taped)	-9.5	3,000			
Powered Capture Hood (grille taped)	-9.5	2,850			
Blower Door (high speed test)	-11.8	4,389	610	0.14	2.8
Blower Door (low speed test)	-7.4	3,313	440	0.13	2.1

Excellent agreement between the two methods with part of the WHF intake grille taped closed so the powered capture hood could be used. The WHF fan opening was larger than the powered flow hood opening. This could be resolved with larger adapters. This house had a problem measuring flow with the Retrotec DM32 gauge operating in the automatic mode. It continued to drift around the zero target and would never give a flow at exactly zero Pa – the three other measurements (DM2 manual, DM2 auto, and DM32 manual) all agreed fine.

House 6: [redacted] **2**, large old conventional WHF, capture hood could not be used since air flow was over 2,000 CFM, the powered capture hood could not be used due to the size and location of the WHF intake grille.

	House Pressure (Pascals)	Total WHF Airflow (CFM)	Total WHF Watt Draw (Watts)	Watts per CFM (Watts/CFM)	Airflow per sq. ft. (CFM/sq. ft.)
Capture Hood					
Blower Door	-8.4	4,050	395	0.09	2.3
Powered Capture Hood					

Capture Hood: Rated for use up to about 2,000 CFM

Blower Door Pressure Matching Method

Powered Capture Hood Method

Conclusion:

In this limited test, agreement between the three proposed measurement methods was within acceptable measurement error of the individual devices. It is the testers' recommendation that all three methods be allowed for confirmation of whole house fan airflows.

HOUSE 1/1

Whole House Fan (WHF) Airflow Measurements

Capture Hood Method

Date 8/31/2017

House Address [redacted]

Tested By Rick

Model of WHF installed TWO - [redacted] (optional)

Listed WHF air flow (cubic feet per minute, CFM) 3,054 CFM TOTAL (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** -7.5 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Total Airflow (CFM)** 1,310 CFM
   (use section below if there is more than one WHF in the house)

   Measured WHF Airflow WHF 1 (CFM) 600 CFM BED 1

   Measured WHF Airflow WHF 2 (CFM) 710 CFM BED 2

   Measured WHF Airflow WHF 3 (CFM) —

   Measured WHF Airflow WHF 4 (CFM) —

   Total WHF Airflow (CFM) 1,310 CFM

3. **Total Measured WHF Watt draw (RMS Watts)** 148

4. **Watts per CFM (calculated, line 3 divided by line 2)** 0.11 W/CFM

5. House CFA (square feet, measured or from plans) 852 ft

6. **WHF Airflow per Square Foot (calculated, CFM/SF, line 2 divided by line 5)** 1.5 CFM/ft

Measurement Equipment:

- [x] Capture Hood – TSI AccuBalance 8380
- [x] Pressure – The Energy Conservatory DG-700 micro manometer
- [ ] Watts – Extech 380940
- [x] Watts – House Revenue Meter

Notes: _____

_____

_____

_____

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 8/31/2017

House Address [redacted]

Tested By Rick

Model of WHF installed TWO - [redacted] (optional)

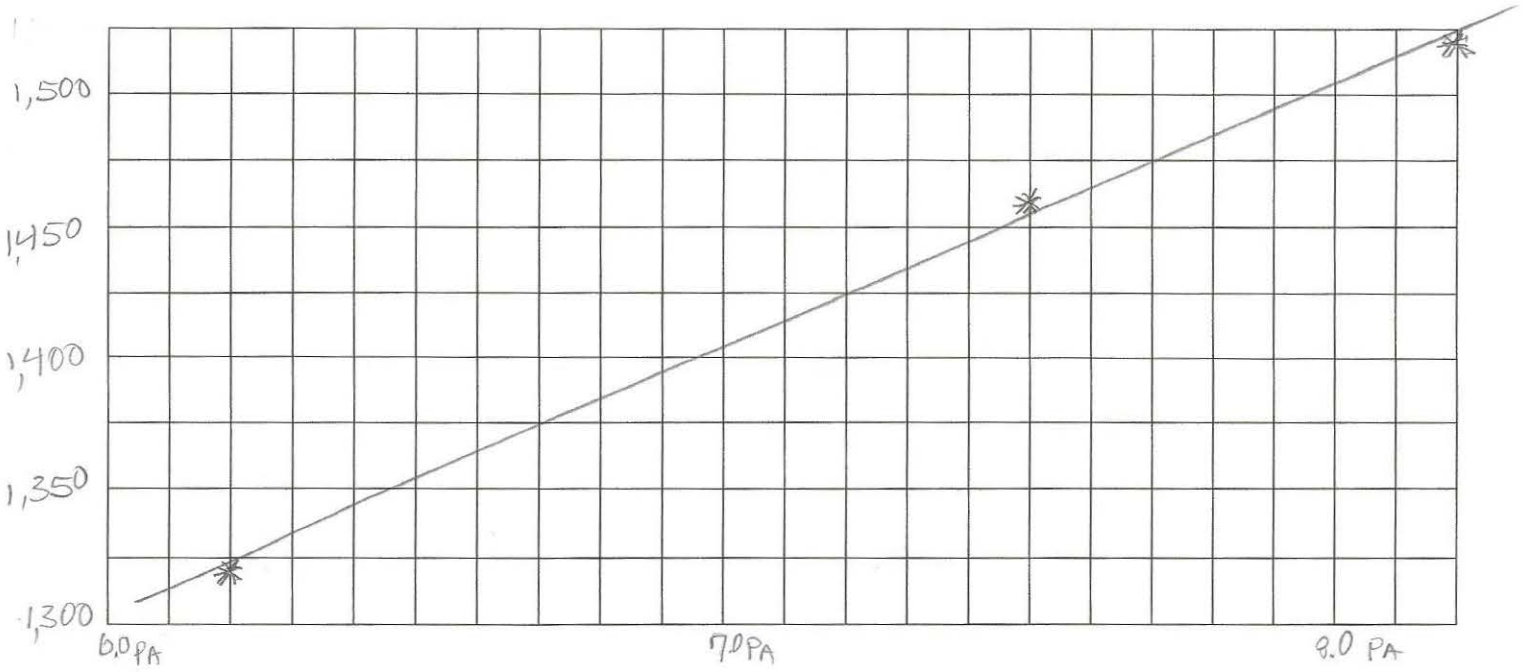
Listed WHF air flow (cubic feet per minute, CFM) 3,054 CFM TOTAL (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −7.5 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 1,303 CFM **at House Pressure (Pa)** −6.2 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 1,460 CFM **at House Pressure (Pa)** −7.5 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 1,523 CFM **at House Pressure (Pa)** −8.2 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 1,460 CFM (from three point graph, or line 3)

6. **Total Measured WHF Watt draw (RMS Watts)** 148 WATTS

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.1 W/CFM

8. House CFA (square feet, measured or from plans) 852 ft

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 1.7 CFM/ft

Measurement Equipment:

- ☒ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☐ Watts – Extech 380940
- ☒ Watts – House Revenue Meter

Notes: 1) TIGHT DAMPERS ON THE TWO W.H.F's - NOT SEALED DURING TEST. 2) THE TEST TOOK 28 MINUTES

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw

Whole House Fan (WHF) Airflow Measurements
Powered Capture Hood Method

Date 8/31/2017

House Address [redacted]

Tested By RUSS KING

Model of WHF installed TWO — [redacted] (optional)

Listed WHF air flow (cubic feet per minute, CFM) 3,054 CFM TOTAL (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −7.5 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Total Airflow (CFM)** 1,662 CFM
   (use section below if there is more than one WHF in the house)

   Measured WHF Airflow WHF 1 (CFM) 797 CFM

   Measured WHF Airflow WHF 2 (CFM) 865 CFM

   Measured WHF Airflow WHF 3 (CFM) —

   Measured WHF Airflow WHF 4 (CFM) —

   Total WHF Airflow (CFM) 1,662 CFM

3. **Total Measured WHF Watt draw (RMS Watts)** 148 WATTS

4. **<u>Watts per CFM</u> (calculated, line 3 divided by line 2)** 0.09 W/CFM

5. House CFA (square feet, measured or from plans) 852 ft

6. **<u>WHF Airflow per Square Foot</u> (calculated, CFM/SF, line 2 divided by line 5)** 2.0 CFM/ft

Measurement Equipment:

- [x] Powered Capture Hood – Retrotec/Sierra Building Science, Inc. Powered Flow Hood conversion
- [x] Pressure – Retrotec DM2
- [ ] Pressure – Retrotech DM32
- [ ] Watts – Extech 380940
- [x] Watts – House Revenue Meter

Notes: 1) THIS TEST TOOK 32 MINUTES

HOUSE 2 / 1

Whole House Fan (WHF) Airflow Measurements
Capture Hood Method

Date 8/31/2017

House Address [redacted]

Tested By Rich

Model of WHF installed THREE – [redacted] (optional)

Listed WHF air flow (cubic feet per minute, CFM) 4,581 CFM TOTAL (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** -8.7 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Total Airflow (CFM)** 1,775 CFM
   (use section below if there is more than one WHF in the house)

   Measured WHF Airflow WHF 1 (CFM) 590 LIVING

   Measured WHF Airflow WHF 2 (CFM) 615 BED 2

   Measured WHF Airflow WHF 3 (CFM) 570 BED 3

   Measured WHF Airflow WHF 4 (CFM) –

   Total WHF Airflow (CFM) 1,775

3. **Total Measured WHF Watt draw (RMS Watts)** 194 WATTS

4. **Watts per CFM (calculated, line 3 divided by line 2)** 0.11 W/CFM

5. House CFA (square feet, measured or from plans) 1,104 ☐

6. **WHF Airflow per Square Foot (calculated, CFM/SF, line 2 divided by line 5)** 1.6 CFM/☐

Measurement Equipment:

- ☒ Capture Hood – TSI AccuBalance 8380
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☐ Watts – Extech 380940
- ☒ Watts – House Revenue Meter

Notes: 1) THIS TEST TOOK 7 MINUTES.

HOUSE 2 / 3

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 8/31/2017

House Address [redacted]

Tested By Rich

Model of WHF installed THREE — [redacted] (optional)

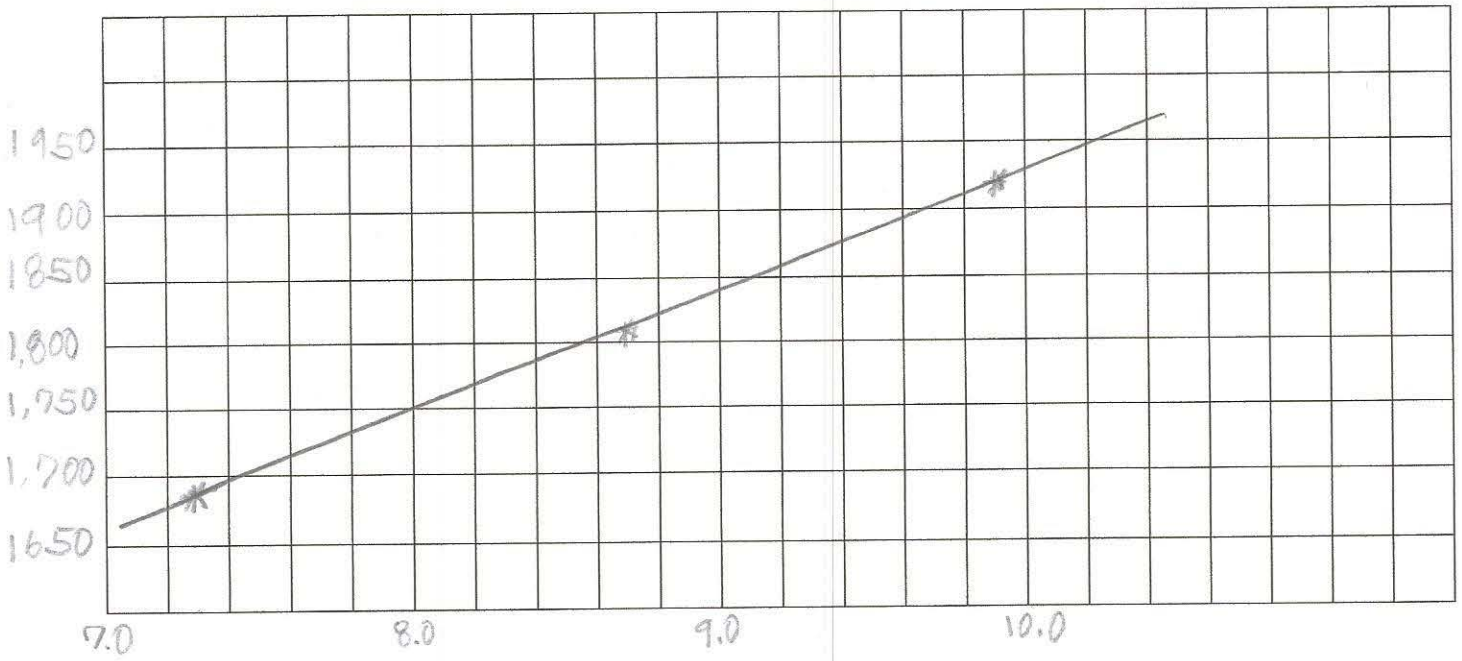
Listed WHF air flow (cubic feet per minute, CFM) 4,581 CFM TOTAL (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −8.7 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 1,689 CFM **at House Pressure (Pa)** −7.3 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 1,804 CFM **at House Pressure (Pa)** −8.7 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 1,922 CFM **at House Pressure (Pa)** −9.9 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 1,804 CFM (from three point graph, or line 3)

6. **Total Measured WHF Watt draw (RMS Watts)** 194 WATTS

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.11 W/CFM

8. House CFA (square feet, measured or from plans) 1,104 ☐

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 1.6 CFM/☐

Measurement Equipment:

- ☒ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☐ Watts – Extech 380940
- ☒ Watts – House Revenue Meter

Notes: 1) W.H.F. DAMPERS NOT SEALED. 2) THIS TEST TOOK 25 MINUTES.

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw

HOUSE 2/5

Whole House Fan (WHF) Airflow Measurements
Powered Capture Hood Method

Date 8/31/2017

House Address [redacted]

Tested By RUSS KING

Model of WHF installed THREE – [redacted] (optional)

Listed WHF air flow (cubic feet per minute, CFM) 4,581 CFM TOTAL (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −8.7 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Total Airflow (CFM)** 1,859 CFM
   (use section below if there is more than one WHF in the house)

   Measured WHF Airflow WHF 1 (CFM) 670 CFM LIVING

   Measured WHF Airflow WHF 2 (CFM) 569 CFM BED 2

   Measured WHF Airflow WHF 3 (CFM) 620 CFM BED 3

   Measured WHF Airflow WHF 4 (CFM) —

   Total WHF Airflow (CFM) 1,859 CFM

3. **Total Measured WHF Watt draw (RMS Watts)** 194 WATTS

4. **Watts per CFM (calculated, line 3 divided by line 2)** 0.10 W/CFM

5. House CFA (square feet, measured or from plans) 1,104 ☐

6. **WHF Airflow per Square Foot (calculated, CFM/SF, line 2 divided by line 5)** 1.7 CFM/☐

Measurement Equipment:

- [x] Powered Capture Hood – Retrotec/Sierra Building Science, Inc. Powered Flow Hood conversion
- [x] Pressure – Retrotec DM2
- [ ] Pressure – Retrotech DM32
- [ ] Watts – Extech 380940
- [x] Watts – House Revenue Meter

Notes: 1) THIS TEST TOOK 44 MINUTES.

HOUSE 4 / 1

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 9/1/2017

House Address [redacted]

Tested By Rick

Model of WHF installed [redacted] (optional)

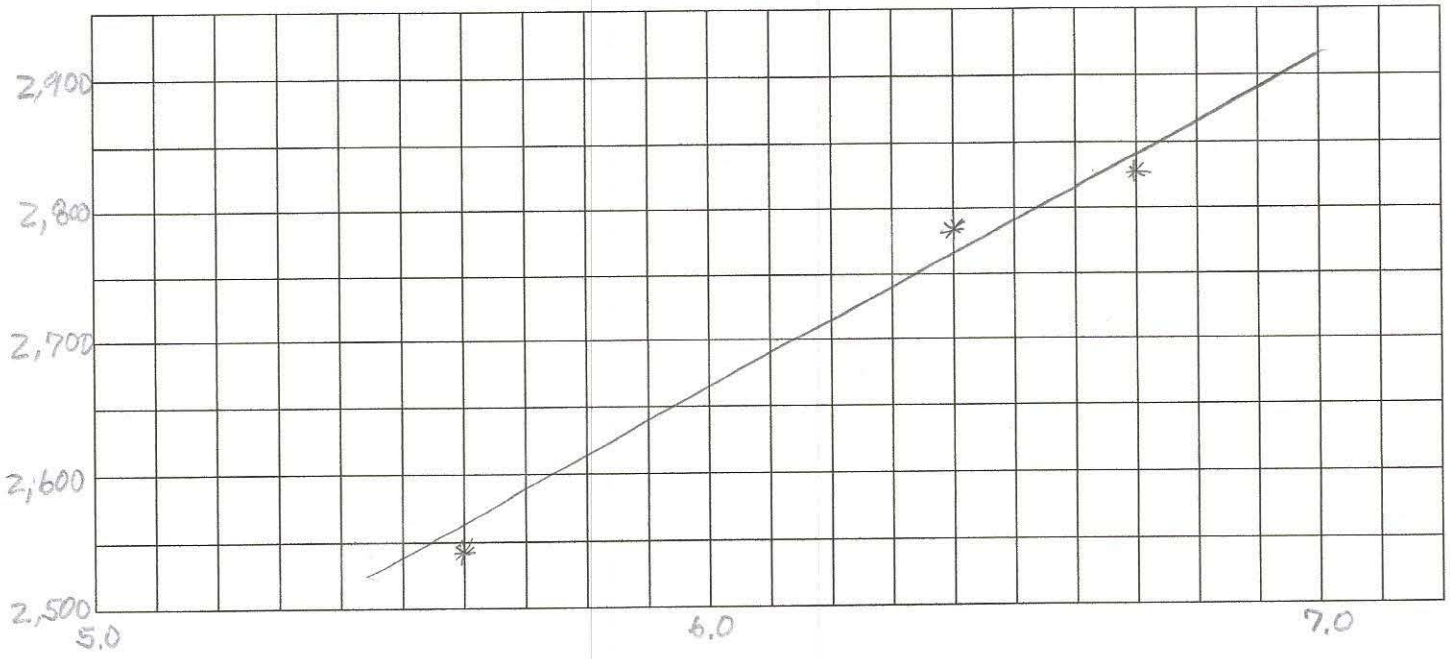
Listed WHF air flow (cubic feet per minute, CFM) 4,940 CFM (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −6.4 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 2,547 CFM **at House Pressure (Pa)** −5.6 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 2,777 CFM **at House Pressure (Pa)** −6.4 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 2,831 CFM **at House Pressure (Pa)** −6.7 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 2,777 CFM (from three point graph, or line 3)

HOUSE 4/2

6. **Total Measured WHF Watt draw (RMS Watts)** 830 W

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.30 W/CFM

8. House CFA (square feet, measured or from plans) 1,830 ft

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 1.5 CFM/ft

Measurement Equipment:

- ☒ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☒ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: 1) THIS TEST TOOK 26 MINUTES. 2) DID NOT SEAL DAMPERS. 3) MEASURED WATTAGES AT ALL 10 SPEEDS: 20/60/120/185/270/360/460/575/700/830 WATTS ON HIGH.

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw

HOUSE 4/3

Whole House Fan (WHF) Airflow Measurements
Powered Capture Hood Method

Date 9/1/2017

House Address [redacted]

Tested By RUSS KING

Model of WHF installed [redacted] (optional)

Listed WHF air flow (cubic feet per minute, CFM) 4,940 CFM (ON HIGH) (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** _____
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)
2. **Measured WHF Total Airflow (CFM)** 2,950 CFM (AVERAGE OF 4 TESTS)
   (use section below if there is more than one WHF in the house)

   Measured WHF Airflow WHF 1 (CFM) 3,000 CFM DM2 MANUAL MODE

   Measured WHF Airflow WHF 2 (CFM) 2,990 CFM DM2 AUTO MODE

   Measured WHF Airflow WHF 3 (CFM) 3,020 CFM DM32 MANUAL MODE

   Measured WHF Airflow WHF 4 (CFM) 2,805 CFM DM32 AUTO MODE

   Total WHF Airflow (CFM) N/A ONLY 1 W.H.F.

3. **Total Measured WHF Watt draw (RMS Watts)** 830
4. **Watts per CFM (calculated, line 3 divided by line 2)** 0.28 W/CFM
5. House CFA (square feet, measured or from plans) 1,830 ☐
6. **WHF Airflow per Square Foot (calculated, CFM/SF, line 2 divided by line 5)** 1.6 CFM/☐

Measurement Equipment:

- ☒ Powered Capture Hood – Retrotec/Sierra Building Science, Inc. Powered Flow Hood conversion
- ☒ Pressure – Retrotec DM2
- ☒ Pressure – Retrotech DM32
- ☒ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: 1) THIS TEST TOOK 20 MINUTES (FOR THE FIRST TEST).

HOUSE 5/1

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 9/1/2017

House Address [redacted]

Tested By RICK

Model of WHF installed CONVENTIONAL OLD W.H.F. (optional)

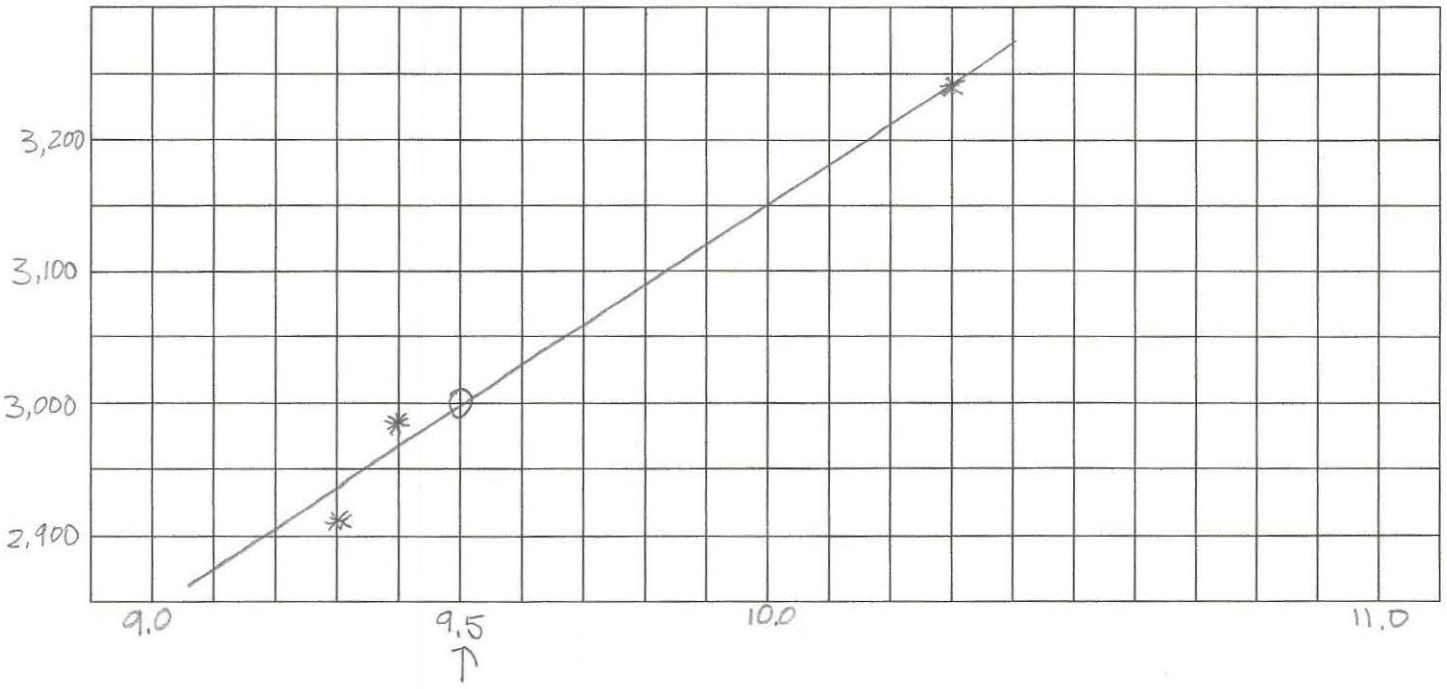
Listed WHF air flow (cubic feet per minute, CFM) DON'T KNOW (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** -9.5 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 2,908 **at House Pressure (Pa)** -9.3 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 2,995 **at House Pressure (Pa)** -9.4 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 3,242 **at House Pressure (Pa)** -10.3 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 3,000 CFM (from three point graph, or line 3) FROM GRAPH

HOUSE 5 / 2

6. **Total Measured WHF Watt draw (RMS Watts)** 610 W

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.20 W/CFM

8. House CFA (square feet, measured or from plans) 1,570 ☆

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 1.9 CFM/☆

Measurement Equipment:

- ☒ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☒ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: 1) THIS TEST WAS WITH PART OF THE DAMPERS TAPED OFF SO THE POWERED FLOW HOOD BOX WOULD FIT THE W.H.F. GRILLE. 2) UN-TAPED FLOW: 4,390 CFM

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw

HOUSE 5 /3

Whole House Fan (WHF) Airflow Measurements
Powered Capture Hood Method

Date 9/1/2017

House Address [redacted]

Tested By RUSS KING

Model of WHF installed CONVENTIONAL OLD W.H.F. (optional)

Listed WHF air flow (cubic feet per minute, CFM) DON'T KNOW (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** -9.5 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Total Airflow (CFM)** 2,850 CFM (AVERAGE OF 3 TESTS)
   (use section below if there is more than one WHF in the house)

   Measured WHF Airflow WHF 1 (CFM) 2,900 CFM DM2 MANUAL MODE

   Measured WHF Airflow WHF 2 (CFM) 2,730 CFM DM2 AUTO MODE

   Measured WHF Airflow WHF 3 (CFM) 2,910 CFM DM32 MANUAL MODE

   Measured WHF Airflow WHF 4 (CFM) 1,900-3,300 CFM DRIFTED IN AUTO MODE W/ DM32

   Total WHF Airflow (CFM) _____

3. **Total Measured WHF Watt draw (RMS Watts)** 610 W

4. **Watts per CFM (calculated, line 3 divided by line 2)** 0.21 W/CFM

5. House CFA (square feet, measured or from plans) 1,570 ft²

6. **WHF Airflow per Square Foot (calculated, CFM/SF, line 2 divided by line 5)** 1.8 CFM/ft²

HOUSE 5/4

Measurement Equipment:

- ☒ Powered Capture Hood – Retrotec/Sierra Building Science, Inc. Powered Flow Hood conversion
- ☒ Pressure – Retrotec DM2
- ☒ Pressure – Retrotech DM32
- ☒ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: 1) TESTED W/ W.H.F. GRILLE PARTIALLY TAPED OFF SO BOX WOULD FIT.

HOUSE 5 / 5

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 9/1/2017

House Address [redacted]

Tested By Rich

Model of WHF installed CONVENTIONAL OLD W.H.F. (ON HIGH) (optional)

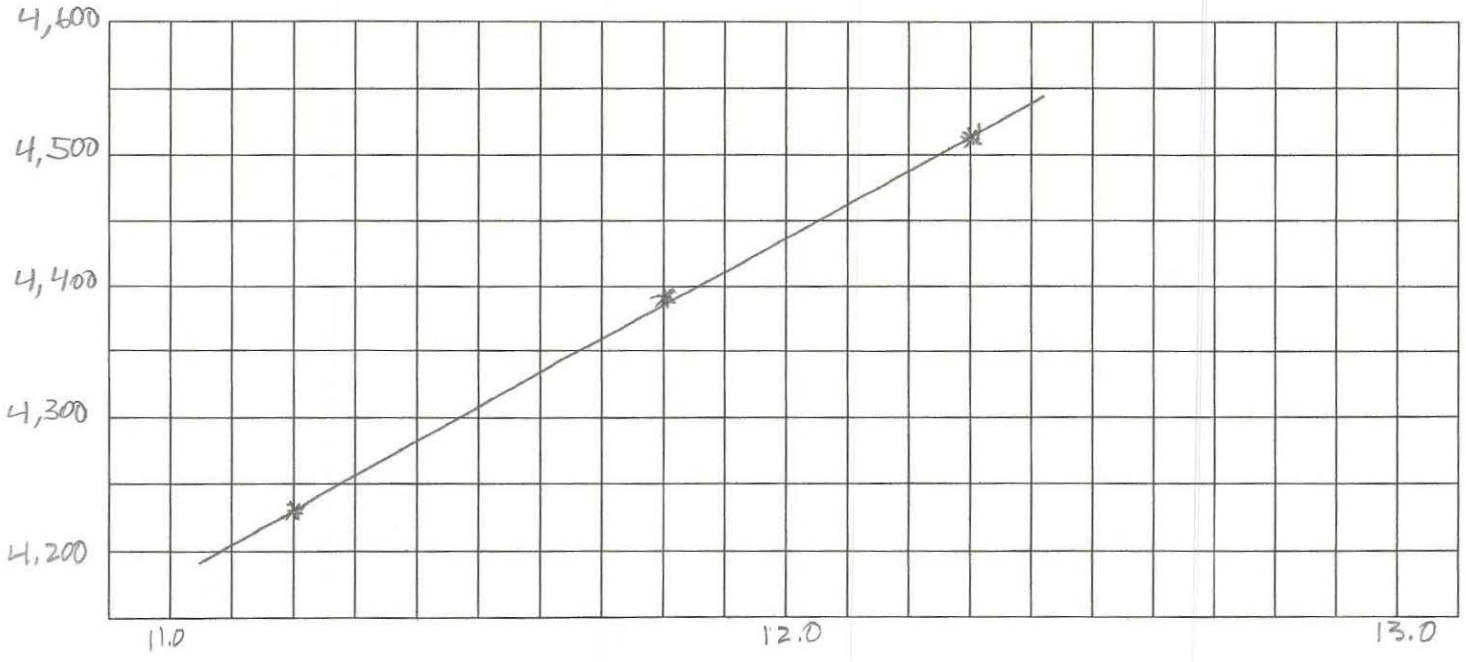
Listed WHF air flow (cubic feet per minute, CFM) DON'T KNOW (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −11.8 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 4,228 CFM **at House Pressure (Pa)** −11.2 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 4,389 CFM **at House Pressure (Pa)** −11.8 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 4,512 CFM **at House Pressure (Pa)** −12.3 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 4,389 (from three point graph, or line 3)

HOUSE 5/6

6. **Total Measured WHF Watt draw (RMS Watts)** 610 W

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.14 W/CFM

8. House CFA (square feet, measured or from plans) 1,570 中

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 2.8 CFM/中

Measurement Equipment:

- ☒ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☒ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: 1) FAN ON HIGH SPEED

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw

HOUSE 5 / 7

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 9/1/2017

House Address [redacted]

Tested By Rich

Model of WHF installed CONVENTIONAL OLD W.H.F. (ON LOW SPEED) (optional)

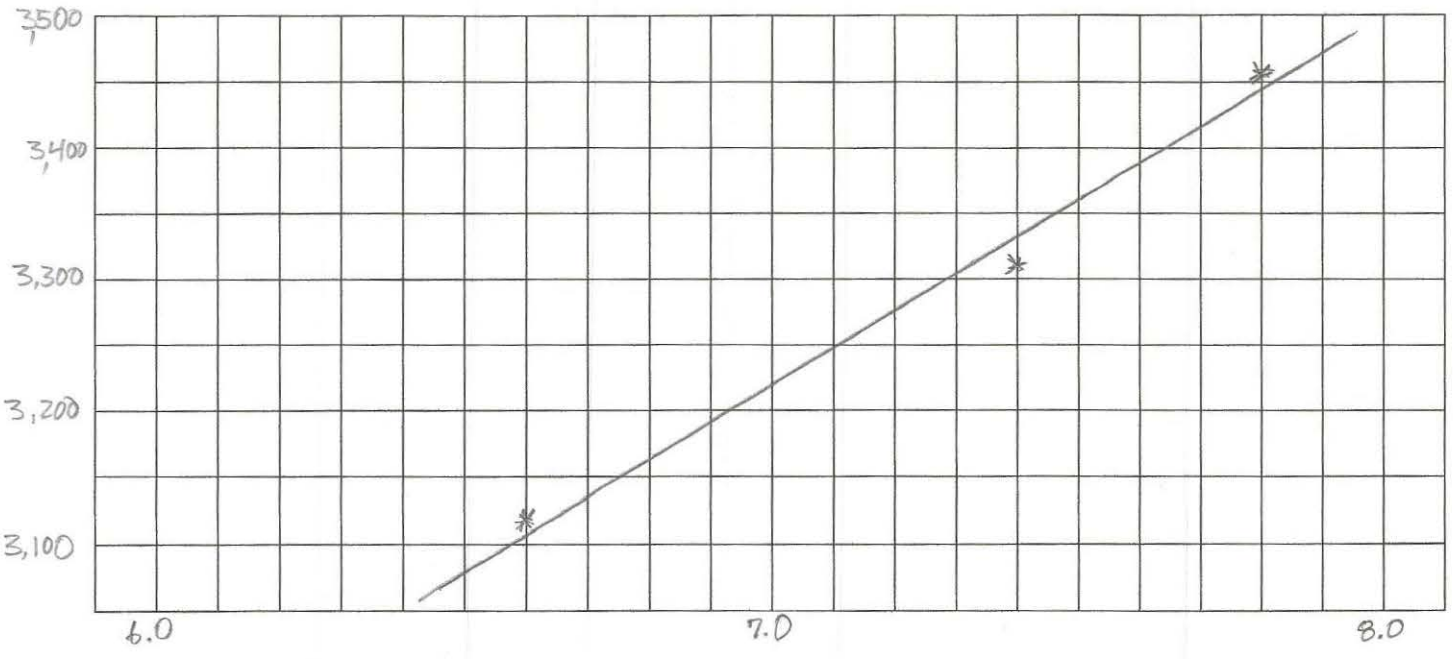
Listed WHF air flow (cubic feet per minute, CFM) NOT KNOWN (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −7.4 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 3,122 CFM **at House Pressure (Pa)** −6.6 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 3,313 CFM **at House Pressure (Pa)** −7.4 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 3,454 CFM **at House Pressure (Pa)** −7.8 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 3,313 CFM (from three point graph, or line 3)

HOUSE 5 / 8

6. **Total Measured WHF Watt draw (RMS Watts)** 440 W

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.13 W/CFM

8. House CFA (square feet, measured or from plans) 1,570 ft

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 2.1 CFM/ft

Measurement Equipment:

- ☐ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☐ Pressure – The Energy Conservatory DG-700 micro manometer
- ☐ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: 1) FAN SPEED ON LOW

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw

HOUSE 6 / 1

Whole House Fan (WHF) Airflow Measurements
Blower Door Pressure Matching Method

Date 9/1/2017

House Address [redacted]

Tested By Rick

Model of WHF installed CONVENTIONAL OLD W.H.F. (optional)

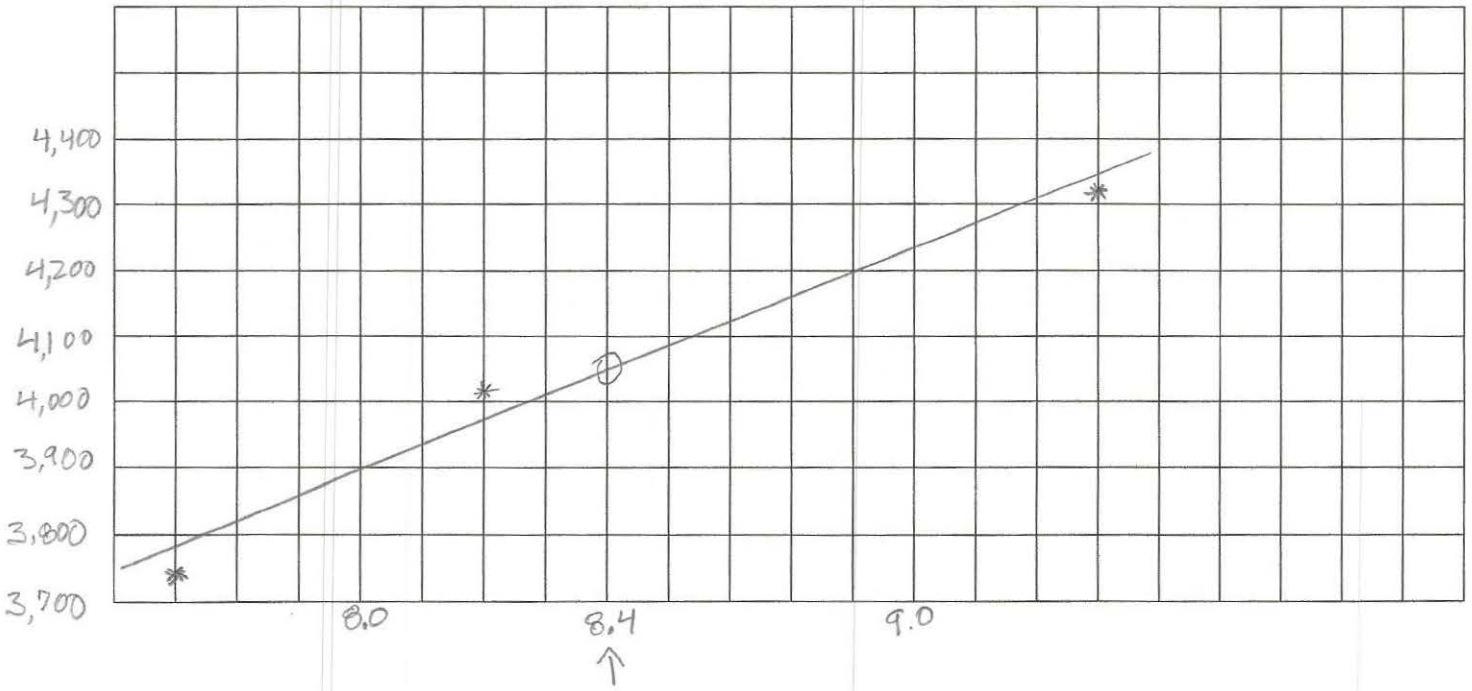
Listed WHF air flow (cubic feet per minute, CFM) DONT KNOW (optional)

1. **Record WHF Negative House Pressure (Pa, WRT outside)** −8.4 PA
   (must be >5.0 Pa, and <15.0 Pa, 1-minute average)

2. **Measured WHF Airflow (CFM)** 3,735 CFM **at House Pressure (Pa)** −7.7 PA
   (slightly below house negative pressure from above, measurements are 1-minute averages)

3. **Measured WHF Airflow (CFM)** 4,014 CFM **at House Pressure (Pa)** −8.2 PA
   (close to, or equal to, house negative pressure from above, measurements are 1-minute averages)

4. **Measured WHF Airflow (CFM)** 4,307 CFM **at House Pressure (Pa)** −9.3 PA
   (slightly above house negative pressure from above, measurements are 1-minute averages)



5. **WHF Airflow (CFM)** 4,050 (from three point graph, or line 3) FROM GRAPH

HOUSE 6/2

6. **Total Measured WHF Watt draw (RMS Watts)** 395 W

7. **<u>Watts per CFM</u> (calculated, line 6 divided by line 5)** 0.09 W/CFM

8. House CFA (square feet, measured or from plans) 1,800 ☆

9. **<u>WHF Airflow per Square foot</u> (calculated, CFM/SF, line 5 divided by line 8)** 2.3 CFM/☆

Measurement Equipment:

- ☒ Blower Door – The Energy Conservatory, Model 3 Blower Door
- ☒ Pressure – The Energy Conservatory DG-700 micro manometer
- ☒ Watts – Extech 380940
- ☐ Watts – House Revenue Meter

Notes: _____

WHF Airflow Measurement Blower Door Procedure:

1. Set up a blower door (BD) as you would for an air infiltration test using negative house pressure. Cap off the fan.
2. Open the window or windows that are typically opened during WHF operation.
3. Turn on the WHF.
4. **<u>Record</u>** the house depressurization "with reference to" (WRT) outside at "WHF normal system operating pressure" (WHF-NSOP). Note: The house negative pressure, WHF-NSOP, must be -5.0 Pa and -15Pa. Use a one-minute average to minimize any wind affects.
5. Turn off the WHF (and seal the WHF opening if the system does not have tight dampers) – but leave the same windows open.
6. Measure house leakage with the blower door three times; once slightly below the WHF-NSOP, once as close as possible to the WHF-NSOP, and once slightly above the WHF-NSOP – and **<u>record</u>** the airflow and pressure at each measurement.
7. Measure and **<u>record</u>** the total fan watt draw