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## 2019 Building Energy Efficiency Standards
## Pre-Rulemaking Workshop

# Residential HVAC, HERS Verification, and Data Registry Requirements

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# Acknowledgements

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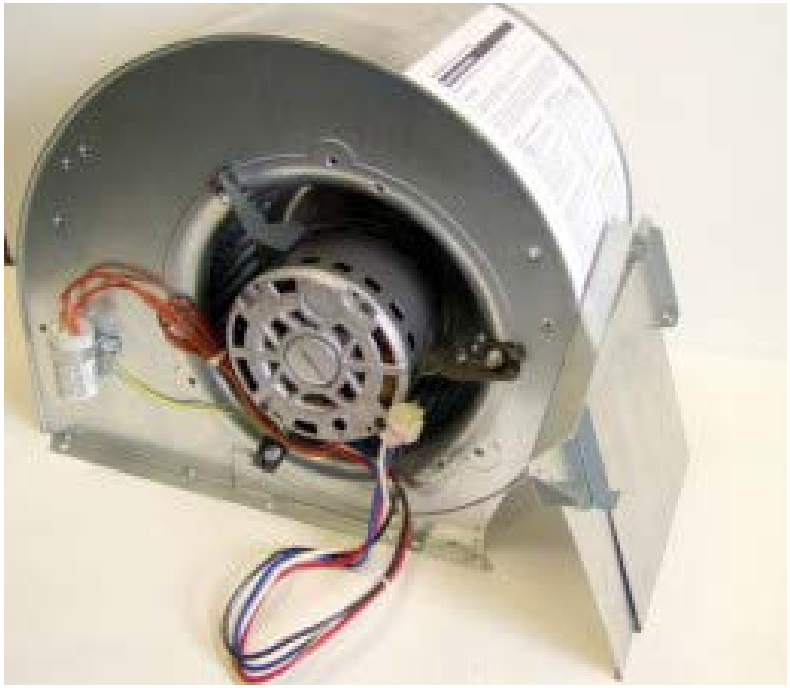
# Agenda

1. Residential HVAC
2. HERS Verification
3. Data Registry Requirements

# Residential HVAC

# Introduction to Fan Efficacy



- Fan efficacy definition:
  - Energy in Watts expended per unit of delivered airflow in cubic feet per minute – (W/cfm)
- Two major characteristics that affect fan efficacy:
  - Motor technology
  - Distribution system design

- Currently, Title 24, Part 6 requires HERS verification of simultaneous compliance with minimum 350 cfm/ton system airflow and maximum 0.58 W/cfm fan efficacy.
  - First adopted in the 2008 code cycle as prescriptive requirement.
  - Subsequently adopted as a mandatory requirement in 2013 code cycle.

# Proposed Code Change – Fan Efficacy

- Revise the maximum fan efficacy requirement in Section 150.0(m)13 and 150.1(c)10.
  - Change to require ≤ 0.45 W/cfm (existing requirement is ≤ 0.58 W/cfm).
  - This is a mandatory requirement applicable to all ducted space cooling systems.
  - This is also a prescriptive requirement in Section 150.1(c)10 applicable to central fan integrated ventilation systems (both heating and cooling systems).
  - Impacts all residential buildings.
  - No change in Table 150.0-B and 150.0-C return duct design compliance alternative which is available as a substitute for HERS verification of fan efficacy.

- Proposed change applies to the following building scope:
  - New systems in newly constructed buildings.
  - Complete system replacements for additions and alterations to existing buildings.

# DOE Standards for Residential Furnace Fan Efficacy

Federal standards that are scheduled to take effect July 3, 2019 place the following limits on fan efficacy. The **fan energy rating (FER**) is defined in Table 1 below. The FER has units of Watt per thousand cfm.

TABLE 1—ENERGY CONSERVATION STANDARDS FOR COVERED RESIDENTIAL FURNACE FANS*

| Product class | FER** (Watts/cfm) |
|---|---|
| Non-Weatherized, Non-Condensing Gas Furnace Fan (NWG–NC) | FER = 0.044 × $Q_{Max}$ + 182 |
| Non-Weatherized, Condensing Gas Furnace Fan (NWG–C) | FER = 0.044 × $Q_{Max}$ + 195 |
| Weatherized Non-Condensing Gas Furnace Fan (WG–NC) | FER = 0.044 × $Q_{Max}$ + 199 |
| Non-Weatherized, Non-Condensing Oil Furnace Fan (NWO–NC) | FER = 0.071 × $Q_{Max}$ + 382 |
| Non-Weatherized Electric Furnace/Modular Blower Fan (NWEF/NWMB) | FER = 0.044 × $Q_{Max}$ + 165 |
| Mobile Home Non-Weatherized, Non-Condensing Gas Furnace Fan (MH–NWG–NC) | FER = 0.071 × $Q_{Max}$ + 222 |
| Mobile Home Non-Weatherized, Condensing Gas Furnace Fan (MH–NWG–C) | FER = 0.071 × $Q_{Max}$ + 240 |
| Mobile Home Electric Furnace/Modular Blower Fan (MH–EF/MB) | FER = 0.044 × $Q_{Max}$ + 101 |
| Mobile Home Non-Weatherized Oil Furnace Fan (MH–NWO) | Reserved |
| Mobile Home Weatherized Gas Furnace Fan (MH–WG)** | Reserved |

* Furnace fans incorporated into hydronic air handlers, SDHV modular blowers, SDHV electric furnaces, and CAC/HP indoor units are not subject to the standards listed in this table.

** $Q_{Max}$ is the airflow, in cfm, at the maximum airflow-control setting measured using the final DOE test procedure at 10 CFR part 430, subpart B, appendix AA.

Source: Federal Register/Vol. 79, No. 128/Thursday, July 3, 2014/Rules and Regulations

Note: There is an error in the Table 1 above. FER is described as representing watts/cfm, but should be watts/thousand cfm.

# DOE Standards for Residential Furnace Fan Efficacy

The **fan energy rating (FER)** calculation is:

$$FER = \frac{(CH \times E_{Max}) + (HH \times E_{Heat}) + (CCH \times E_{Circ})}{(CH + 830 + CCH) \times Q_{Max}} \times 1000$$

Where:

CH = Cooling operating hours

HH = Heating operating hours

CCH = Constant circulation operating hours

$E_{Max}$ = Furnace fan energy at maximum speed (watts)

$E_{Heat}$ = Furnace fan energy at the default heating speed (watts)

$E_{Circ}$ = Furnace fan energy at the default constant circulation speed (watts)

$Q_{Max}$ = Airflow at maximum fan speed (cfm)

# DOE Standards for Residential Furnace Fan Efficacy

Testing is conducted at the following conditions and fan speed settings:

TABLE III.1—REQUIRED REFERENCE SYSTEM CRITERIA (I.E., ESP AT MAXIMUM AIRFLOW) BY FURNACE FAN INSTALLATION TYPE

| Installation type | ESP at maximum airflow (in. wc) |
|---|---|
| Units with an internal evaporator coil | 0.50 |
| Units designed to be paired with an evaporator coil | 0.65 |
| Units designed to be installed in a mobile home [12] | 0.30 |

TABLE III.2—AIRFLOW-CONTROL SETTINGS AT WHICH MEASUREMENTS ARE REQUIRED FOR EACH PRODUCT TYPE

| Product type | Airflow-control setting 1 | Airflow-control setting 2 | Airflow-control setting 3 |
|---|---|---|---|
| Single-stage Heating | Default constant-circulation | Default heat | Absolute maximum.* |
| Multi-stage or Modulating Heating | Default constant-circulation | Default low heat | Absolute maximum. |

*For the purposes of the test procedure, "absolute maximum" airflow-control setting refers to the airflow-control setting that achieves the maximum attainable airflow at the operating conditions specified by the test procedure.

# DOE Standards for Residential Furnace Fan Efficacy

The DOE operating hour assumptions are:

TABLE III.3—ESTIMATED NATIONAL AVERAGE OPERATING HOUR VALUES FOR CALCULATING FER

| Operating mode | Variable | Single-stage (hours) | Multi-stage or modulating (hours) |
|---|---|---|---|
| Heating | HH | 830 | 830/HCR |
| Cooling | CH | 640 | 640 |
| Constant Circulation | CCH | 400 | 400 |

This means that the power portion of the FER rating is a function of three fan speeds, weighted by operating hours.

For a single stage furnace the weightings are:

- 44% Heating speed
- 34% Cooling speed
- 21% Constant circulation speed

# DOE Standards for Residential Furnace Fan Efficacy

- The calculated FER value has units of watts per thousand cfm.
- But the calculated FER value does not represent the watts per thousand cfm that would be expected at system cooling speed (high speed), since FER is a weighted combination of heating (44%), cooling (34%) and constant circulation (21%) speeds.

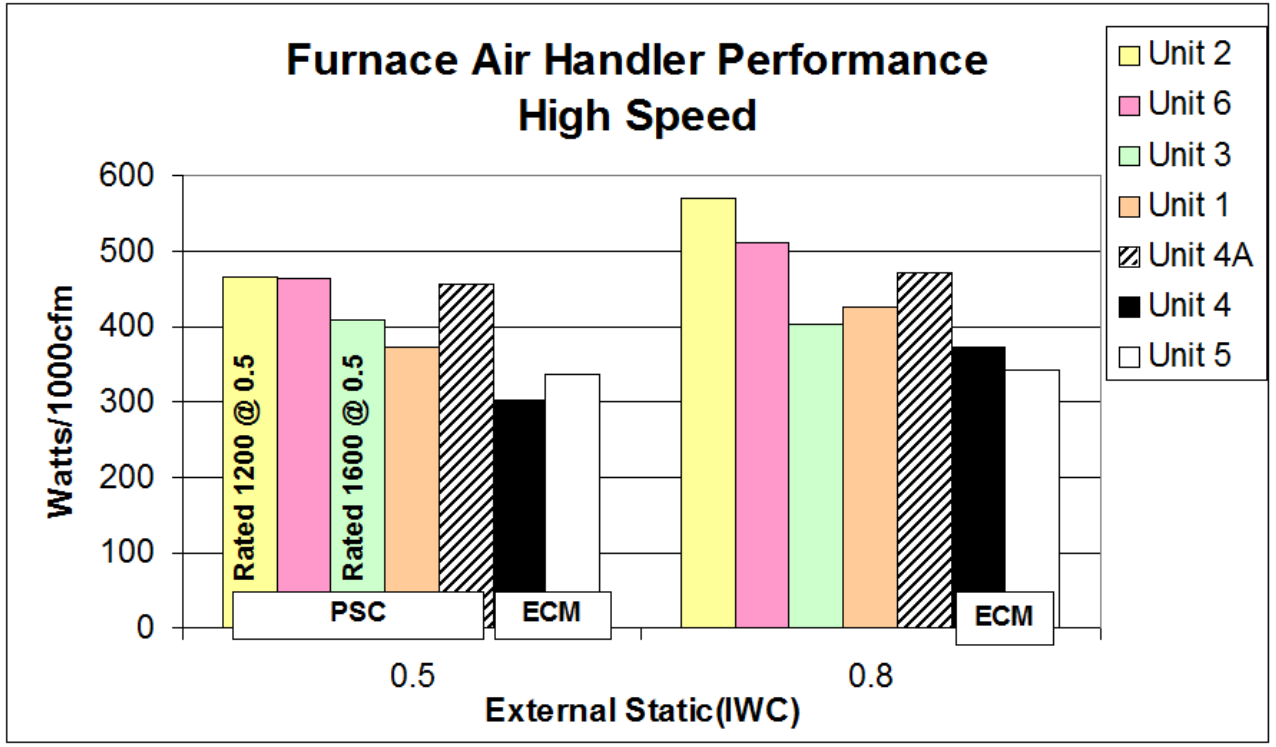
- Thus it is not possible to make a direct comparison between the FER rating and the cooling mode fan efficacy specified in Title 24.
- And it is not possible to determine a cooling speed W/cfm from the FER rating with any degree of confidence since 2/3 of the rating is based on heating and circulation operating modes.

- It is unlikely that a furnace would be capable of meeting the FER standard unless it's motor efficiency is similar to that of a brushless permanent magnet (BPM) motor.

- Thus the new Federal standard is expected to cause all furnaces to use BPM fan motors in place of the current standard PSC motors.

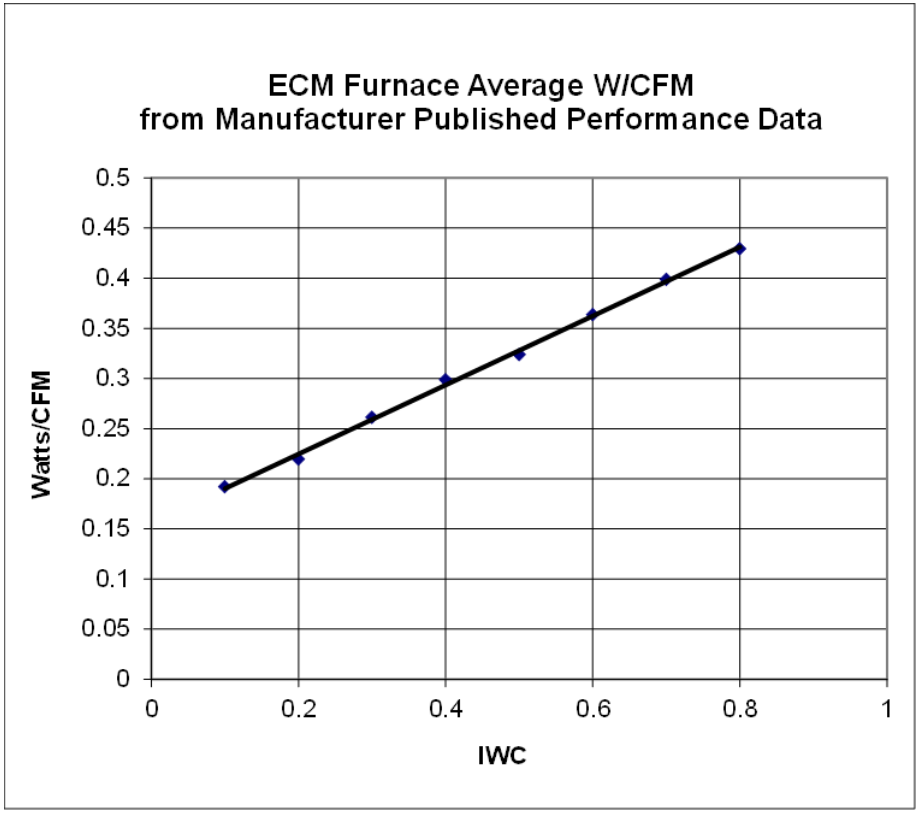
## Are BPM furnaces capable of meeting a requirement of 0.45 W/cfm in CA homes?

Furnace testing by Proctor Engineering Group for the Energy Commission in 2006 shows two BPM (ECM) furnaces (Units 4 and 5) operating between 0.3 and 0.4 watts per cfm at realistic external static pressures for CA homes.

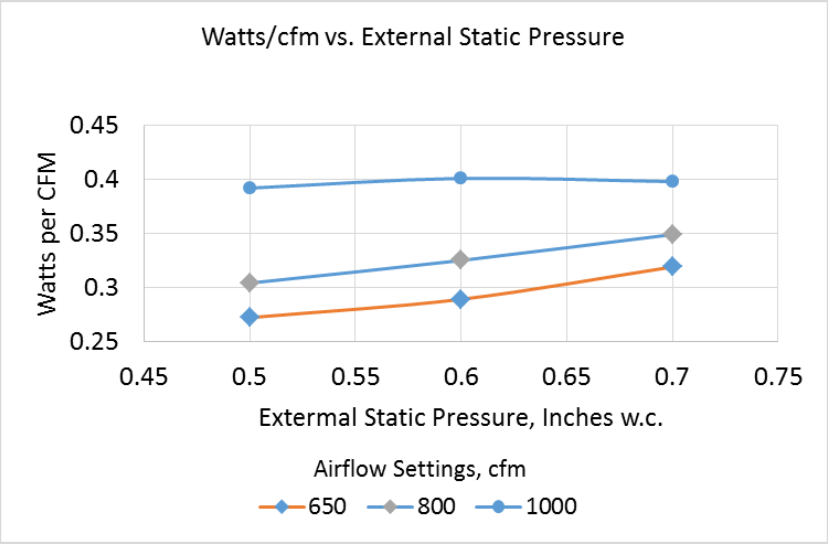


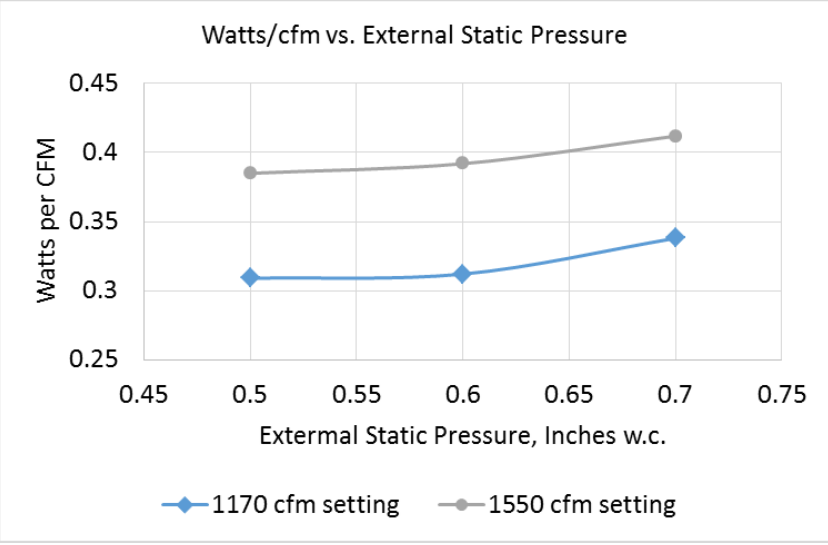
A furnace model database compiled by LBNL in 2004 provides BPM furnace characteristics based on manufacturer expanded performance ratings similar to those measured by Proctor Engineering Group in the laboratory. The data indicate that, at an external static pressure of 0.7 inches w.c the fans would comply.

Lutz J et al., Modeling Energy Consumption of Residential Furnaces and Boilers in U.S. Homes, LBNL-53924, 2004



The Statewide CASE Team tested two BPM-equipped furnaces, one rated at 1,000 cfm maximum that uses a constant torque motor, and the other rated at 1,600 cfm maximum that uses a motor that behaves like a constant cfm type. Results indicate that, at an external static pressure of 0.7 inches w.c the fans would comply.



# Incremental Costs, Benefit-to-Cost Ratio, Cost Effectiveness Analysis

- The incremental cost is assumed to be zero.
- The measure is cost effective in all climate zones.

Rationale:

- The only change is to use a lower Watt/cfm compliance criterion, and the federal standards will enable a lower Watt/cfm for furnaces.
- Compliance with Table 150.0-B and C is not changing.
- No added costs are expected – only savings.

Assumptions:

- DOE FER standard in effect
- No incremental maintenance costs

# Definition of Baseline and Proposed Conditions

**Baseline Conditions**

- Minimally compliant with 2016 Standards
- 2,100 $ft^2$ and 2,700 $ft^2$ single family prototypes
- 6,960 $ft^2$ 8-unit multifamily prototype
- 2019 TDV values
- Ventilation loads adjusted for 2016 ASHRAE 62.2 ventilation rates

**Proposed Conditions – Fan Efficacy**

- 0.45 W/cfm airflow

# Fan Efficacy - Annual TDV and Cost Savings Per Average Dwelling Unit (SF & MF combined)

| Climate Zone | TDV Energy Savings (TDV kBtu/yr) | 30 Year TDV Energy Cost Savings ($2020) |
|---|---|---|
| **1** | 1,197 | $ 207 |
| **2** | 1,064 | $ 184 |
| **3** | 362 | $ 63 |
| **4** | 1,242 | $ 215 |
| **5** | 331 | $ 57 |
| **6** | 703 | $ 122 |
| **7** | 332 | $ 57 |
| **8** | 1,435 | $ 248 |
| **9** | 2,197 | $ 380 |
| **10** | 3,338 | $ 577 |
| **11** | 5,287 | $ 915 |
| **12** | 3,267 | $ 565 |
| **13** | 6,681 | $ 1,156 |
| **14** | 4,917 | $ 851 |
| **15** | 10,993 | $ 1,902 |
| **16** | 1,863 | $ 322 |

# Fan Efficacy - Annual Energy Savings Per Average Dwelling Unit (SF & MF combined)

| Climate Zone | Annual Electricity Savings (kWh/yr) | Annual Natural Gas Savings (kWh/yr) | Peak Electric Demand Reduction (kW) |
|---|---|---|---|
| **1** | 64 | -3 | 0.00 |
| **2** | 40 | -2 | 0.01 |
| **3** | 17 | -1 | 0.00 |
| **4** | 30 | -1 | 0.02 |
| **5** | 18 | -1 | 0.00 |
| **6** | 13 | 0 | 0.02 |
| **7** | 6 | 0 | 0.01 |
| **8** | 18 | 0 | 0.04 |
| **9** | 29 | 0 | 0.06 |
| **10** | 47 | -1 | 0.09 |
| **11** | 120 | -2 | 0.10 |
| **12** | 58 | -2 | 0.06 |
| **13** | 128 | -2 | 0.14 |
| **14** | 109 | -2 | 0.10 |
| **15** | 268 | 0 | 0.18 |
| **16** | 82 | -3 | 0.02 |

# HERS Verification

## New HERS Verification Protocols

- Heat Pump Capacity Verification
- Whole House Fan (WHF) Airflow Rate Verification
- Central Fan Ventilation Cooling System (CFVCS) Verification
- Kitchen Range Hood - HVI Certification Verification
- Multifamily Building Central Ventilation Shaft or Duct Leakage Verification

## Modifications to Existing HERS Verification Procedures

- Update RA3.8 Field Verification and Diagnostic Testing of Building Air Leakage
- Third Party Quality Control Program (TPQCP) - Clarify and Update Specifications and Procedures – RA2.4.3 and RA2.7

# New HERS Verification Protocols

- **Heat Pump Capacity Verification**
  - Performance compliance encourages heat pump sizing that minimizes use of resistance heating backup, so verification of the installed ratings for the proposed heat pump capacity is performed.
  - Verification utilizes certified rating data from the AHRI directory or another directory of certified product performance ratings
  - Procedure consists of visual verification of:
    - AHRI certification for the installed equipment manufacturer model numbers
    - AHRI heating capacity at 47°F and 17°F

# New HERS Verification Protocols

- **Whole House Fan (WHF) Airflow Rate Verification**
  - HERS verification is proposed in order to address concerns that some installed WHFs are not delivering the required airflow rate.
  - Energy savings due to use of a WHF for ventilation cooling is only realized if the installed WHF provides the required airflow rate when operated.
  - Two WHF airflow measurement alternatives are proposed to be added to Reference Appendix RA3 for use for demonstrating compliance:
    - A blower door measurement using a pressure matching technique similar to the HVAC system duct leakage pressure matching protocol in RA3.3.3.1.1.
    - A powered flow capture hood measurement using a technique similar to the HVAC system airflow rate measurement protocol in RA3.3.3.1.3. A powered flow capture hood attachment designed for use with a blower door fan flowmeter is used for this procedure.
  - Verification of the required attic vent area is proposed (detail protocol TBD).
  - Verification of the installed WHF Watt/cfm is proposed (detail protocol TBD).

# New HERS Verification Protocols

## Summary of Whole House Fan (WHF) Airflow Rate Measurement

- **Using a Blower Door and Pressure Matching:**
  - Set up a blower door (BD) as you would for an air infiltration test using positive house pressure. Cap off the blower door fan.
  - Open the window or windows that are typically opened during WHF operation.
  - Turn on the WHF.
  - At “WHF normal operating conditions” record the house depressurization with reference to (WRT) outside.
  - Remove the BD fan cover.
  - Close all the windows.
  - Increase the BD fan speed to match the house depressurization recorded under “WHF normal operating conditions”.
  - Record the BD air flow which is also the WHF air flow.
- **Using Powered Flow Capture Hood:**
  - Open the window or windows that are typically opened during WHF operation.
  - Turn on the WHF.
  - Measure the WHF airflow using a calibrated powered flow capture hood.

# New HERS Verification Protocols

- **Central Fan Ventilation Cooling System (CFVCS) Verification**
  - The 2013 BEES CASE report called for HERS verification of CFVCSs, but staff neglected to include a HERS protocol in RA3. This is to complete that process.
  - Energy savings due to a CFVCS is only realized if the installed CFVCS is operated to meet the proposed CFVCS airflow rate requirement specified on the Certificate of Compliance.
  - The field verification procedure uses the same system airflow rate measurement protocols as are used for verification of full system airflow (RA3.3.3) as follows:
    - In addition to complying with duct leakage, airflow rate, and fan efficacy verifications applicable to non-CFVCS air-handlers, also measure and confirm that CFVCS airflow and fan efficacy meets the value specified on the Certificate of Compliance while the system is operating in ventilation-only mode.
    - Verify the manufacturer model is certified to the Energy Commission as a CFVCS.
    - Verify attic vent free area.
    - Verify central fan type (fixed or variable flow).
    - Verify outdoor temperature sensor.

# New HERS Verification Protocols

- **Kitchen Range Hood - HVI Certification Verification**
  - HERS Verification is proposed to improve compliance with the ASHRAE 62.2 requirement for use of HVI certified kitchen range hood fans.
  - Procedure:
    - Record the manufacturer model number for the installed kitchen range hood.
    - Reference the certified performance rating data in the HVI directory for the installed kitchen range hood.
    - Verify that the HVI certified performance listed for the installed kitchen range hood meets the required airflow and sone ratings required by ASHRAE 62.2.

# New HERS Verification Protocols

- **Multifamily Building Central Ventilation Shaft or Duct Leakage**
  - The procedure is new for 2019
  - Procedure is a modification of the duct leakage protocols already specified in RA3.1.4.3.1 Diagnostic Duct Leakage from Fan Pressurization of Ducts.
    - Seal all grilles and registers
    - Attach a fan flowmeter and pressurize to 25 Pa (0.1 inches water)
    - Record the flow through the meter
    - Divide the leakage flow by the total ventilation system airflow and convert to a percentage.
    - The leakage flow must be equal to or less than 6% of the total ventilation system airflow.

# Modifications to Existing HERS Verification Protocols

- **Update RA3.8 Field Verification and Diagnostic Testing of Building Air Leakage**
  - Update the field diagnostic protocol language to be consistent with the new version of the RESNET standard (ANSI/RESNET/ICC 380-2016)
  - Limit the protocol options to only use of the One-Point (Single-Point) test.
    - Efficiency Characteristics and Opportunities for New California Homes (Proctor, Chitwood, Wilcox, 2011) concludes that a single-point method at 50 pascals provides results within 5% of the other methods.
    - Eliminating optional use of the Multi-Point test and Repeated Single-Point tests will simplify the protocol and eliminate 6 Compliance Documents.

# Modifications to Existing HERS Verification Procedures – RA2

- **Third Party Quality Control Program (TPQCP) - Clarify and Update Specifications and Procedures – RA2.4.3 and RA2.7**

  - Field diagnostic instrumentation has evolved over the years since TPQCP was first conceived, therefore it is necessary to revisit the expectation for the functionality of the diagnostic tools and diagnostic software a TPQCP uses.
  - Wireless network connectivity for field diagnostic equipment, cloud-based data logging, and sophisticated diagnostic software has become widely available for use by any HERS rater.
  - Data transmittal relationships between new cloud-based data services and HERS Data Registries are expected to be clarified in Joint Appendix JA7 (Data Registry Requirements) which will impact clarification of the data transmittal relationships between TPQCP services and the Data Registries they are approved to use for HERS verification compliance of their installations.
  - Clarification of procedures for TPQCP approval, and QA oversight are needed.

# Data Registry Requirements

# Data Registry Requirements Updates

- **Joint Appendix JA7 – Data Registry Requirements, and Data Registry Requirements Manual**
  - Portions of the Data Registry Requirements Manual that are well established features that are implemented by all HERS Providers will be moved into JA7.
  - JA7.8 - Data Registry Approval, will be updated to clarify the data registry approval procedures.
  - JA7.9 will be rewritten to specify the approval procedures for data transmittal services between Data Registries and cloud-based data services such as those used by diagnostic tool manufacturers. These data transmittal procedures are an alternative to current keyboard input of information for completing and registering Title 24 Part 6 compliance documents.

Questions?

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