



U.S. Codes, Standards, and Regulations for Large Diameter Ceiling Fans

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- Staff Liaison, N.A. Air Movement Advocacy Committee



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U.S. Codes, Standards, and Regulations for Large Diameter Ceiling Fans

Purpose

The purpose of this presentation is to detail the LDCF provisions in NFPA, ASHRAE, and ICC codes and standards, and to instruct on the U.S. Department of Energy regulation and its metric-change to CFEI. The webinar also will briefly describe the AMCA test standard for LDCF, and how AMCA tests and certifies LDCF products.

U.S. Codes, Standards, and Regulations for Large Diameter Ceiling Fans

Learning Objectives

At the end of this presentation, you will be able to:

1. Describe LDCF provisions in some energy, fire, and mechanical codes and standards.
2. Describe the U.S. Department of Energy regulation and the new LDCF efficiency metric, Ceiling Fan Energy Index (CFEI).
3. Identify the AMCA test standard for LDCF and how these products are tested and certified by AMCA.

Today's Presenters

- **Aaron Gunzner:** LDCF Provisions in NFPA, ASHRAE, ICC
- **Michael Ivanovich:** Basics of Federal Regulations for Large Diameter Ceiling Fans
- **Christian Taber:** New Metric for LDCF Efficiency Regulations: Ceiling Fan Energy Index (CFEI)
- **Nazme Mohsina:** LDCF Testing and Certification

Michael Ivanovich

Sr. Director, Global Affairs, AMCA International

Presenter

- Joined AMCA July 2011
- Coordinates advocacy in N. America, Asia, Europe, and Middle East
- Leads AMCA energy efficiency initiatives involving codes, standards and regulations
- M.Sc. Civil Engineering (Building Systems)



Christian Taber

Principal Engineer - Codes & Standards, AMCA Member Company

Presenter

- M.S. in mechanical engineering & biosystems engineering; B.S. in chemical engineering
- ASHRAE certified High-Performance Building Design Professional and Certified Energy Manager
- Chair, N.A. Air Movement Advocacy Committee
- Served on AMCA committees 230, 214, 211, 208 and 11 and ASHRAE – Standards Committee, SSPC 90.1



Nazme Mohsina

Technical Director, AMCA
International

Presenter

- Joined AMCA in 2011
- Oversees the AMCA headquarters laboratory; administers the Certified Ratings Program (CRP)
- Holds a bachelor's degree in electrical and electronic engineering, and a master's degree in electrical engineering
- In 2020, was named to Engineered Systems magazine's list of "20 to Watch: Women in HVAC"



Handouts for This Webinar

- PDF of the presentation
- CFEI Changes to Code of Federal Regulations
- “Cheat Sheet” of useful hyperlinks to LDCF resources



LDCF Provisions in NFPA, ASHRAE, ICC

LDCF Provisions in NFPA 13-2019

- NFPA Standard 13, *Standard for the Installation of Sprinkler Systems*

- Definition: “**3.3.93 High Volume Low Speed Fan.**

A ceiling fan that is approximately 6ft (1.8m) to 24ft (7.3m) in diameter with a rotational speed of approximately 30 to 70 revolutions per minute.”

- DOE definition of LDCF starts at 7-ft and includes fans without HVLS properties,
- So, NFPA definition does not align with federal law definition
- Diameter paired with RPMs is vague about whether it applies to a product or not
- AMCA may propose changes in next revision cycle

LDCF Provisions in NFPA 13-2019

- Sections 19.2.7, 20.6.7 - installation of HVLS Fans:
 1. Max. fan diameter shall be 24ft (7.3m)
 2. Centered approximately between four adjacent sprinklers
 3. Vertical clearance from fan to sprinkler deflector shall be minimum of 3ft (0.9m)
 4. All HVLS fans shall be interlocked to shut down immediately upon a waterflow alarm. (In accordance with NFPA 72 where applicable.)
- Annex A – Explanatory Material
 - Shutdown within 90 sec by the VFD; based on 2011 research

LDCF Provisions in NFPA 72-2019

- NFPA Standard 72, *National Fire Alarm and Signaling Code*®
- Section 21.8 HVLS Fans.
 - “Where required by NFPA 13, all HVLS fans shall be interlocked to shut down upon actuation of a sprinkler waterflow switch that indicates waterflow in the area served by the fans.”

LDCF Provisions in ASHRAE 90.1-2019

- *Energy Standard for Buildings Except Low-Rise Residential Buildings*
- Addresses holes in DOE compliance certification requirements
- Does not include new CFEI requirements
 - AMCA will be proposing an addendum to add more to this provision

LDCF Provisions in ASHRAE 90.1-2019

- “Section 6.4.1.3 Ceiling Fans

Large-diameter ceiling fans shall be rated in accordance with 10 CFR 430 Appendix U or AMCA 230. The following data shall be provided:

- a. Blade span (blade tip diameter)
- b. Rated airflow and power consumption at the maximum speed

- 6.4.1.3.1

The data provided shall meet one of the following requirements:

- a. It is determined by an independent laboratory.
- b. It is included in a database published by USDOE.
- c. It is certified under a program meeting the requirements of Section 6.4.1.5.

- Exception to 6.4.1.3.1

Ceiling fans not covered in the scope of 10 CFR Part 430.”

LDCF Provisions in IMC and IECC

- International Mechanical Code (IMC) and International Energy Conservation Code (IECC)
- 2018 IMC Section 929.1; 2021 IMC Section 930.1 – Large-Diameter Ceiling Fans
 - “Where provided, large-diameter ceiling fans shall be tested and labeled in accordance with AMCA 230, listed and labeled in accordance with UL 507, and installed in accordance with the manufacturer’s instructions.”
- 2021 IECC Section C403.9 – Large-diameter ceiling fans.
 - “Where provided, large-diameter ceiling fans shall be tested and labeled in accordance with AMCA 230.”



Basics of Basics of Federal Regulations for Large Diameter Ceiling Fans

U.S. Large Diameter Ceiling Fan Regulation

- Prior to the U.S. DOE regulation ceiling fan regulations were state-by-state, leading to a variety of efficiency metrics and test standards.
- The DOE regulation preempted state regulations and established uniform test methods, metrics, and requirements
- DOE "product" regulations are legally enforceable provisions of the U.S. Code of Federal Regulations
- Developed and enforced by the U.S. DOE Appliance and Equipment Standards Program

U.S. Large Diameter Ceiling Fan Regulation

- Basics
 - A federal energy efficiency regulation has two main parts:
 - Test Procedure
 - Energy Conservation Standard
 - Test procedure is *a regulation* that defines
 - Regulatory metric and method(s) of test, including start date
 - Product classes
 - Scope - covered and excluded products
 - Energy conservation standard establishes
 - Design criteria
 - Minimum efficiency performance standard (MEPS) by product class
 - Compliance filing requirements, including start date of enforcement
 - Enforcement provisions (surveillance), including testing, penalties
 - Administrative laws such as these are published in the U.S. Code of Federal Regulations (CFR)

U.S. LDCF Regulation

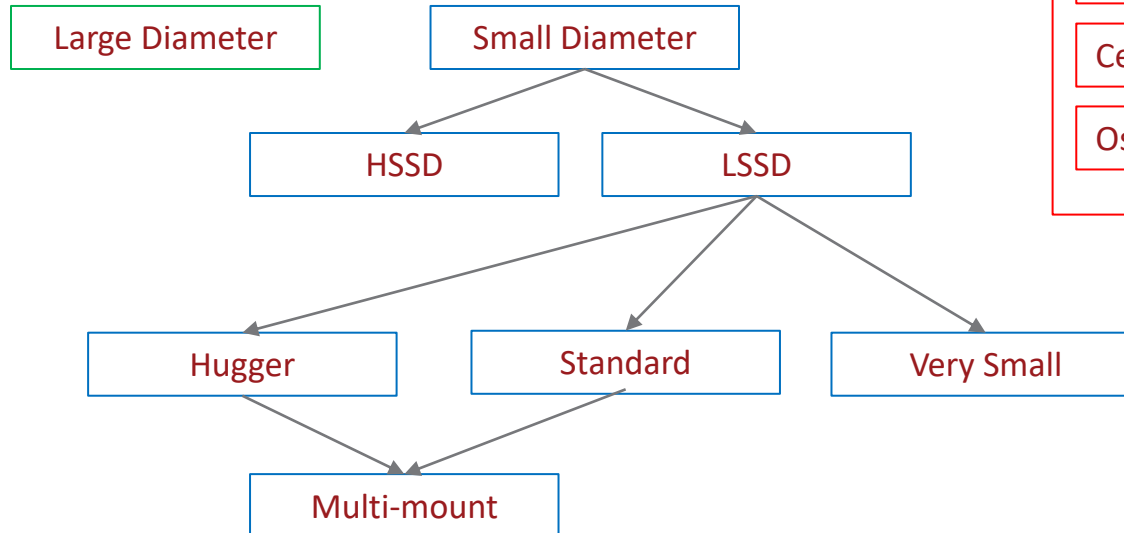
- Basics

- Test Procedure

- Use “definitions” to establish product classes and regulatory metrics
 - Establishes a uniform test procedure for all covered products
 - DOE will consider industry test standards and not use, use, or refine
 - Ceiling fan test procedures published July 24, 2016
 - LDCF use ANSI/AMCA 230-15
 - Other product classes use a different procedure
 - “On or after January 23, 2017, manufacturers of ceiling fans...must make any representations with respect to energy use or efficiency in accordance with the results of testing pursuant to this appendix.”

Product Classes

All product classes that are covered or exempt must be explicitly defined.



Exempt Fans

Highly Decorative

Belt Driven

Centrifugal

Oscillating

U.S. LDCF Regulation

- *Establishment of the LDCF Product Class:*
 - *(10 CFR 430.2 – Definitions). The term “ceiling fan” means a nonportable device that is suspended from a ceiling for circulating air via the rotation of fan blades.*
 - *(10 CFR 430, Appendix U to Subpart B (1.11)). Large-diameter ceiling fan means a ceiling fan that is greater than seven feet in diameter.*
 - ...
- *Establishment of the LDCF Test Procedure:*
 - *(10 CFR 430, Appendix U to Subpart B (3.4)). The test apparatus and instructions for testing large-diameter ceiling fans must conform to the requirements specified in sections 3 through 7 of AMCA 230-15 ...with the following modifications:*
 - 3.4.1. The test procedure is applicable to large-diameter ceiling fans up to 24 feet in diameter.
 - Etc.

U.S. Ceiling Fan Regulation

- Basics
 - Energy conservation standard establishes
 - Design criteria
 - Minimum efficiency performance standard (MEPS)
 - Exempt product classes
 - Compliance filing requirements, including start-date of enforcement
 - Enforcement provisions (surveillance), including testing, penalties
 - Final rule published January 19, 2017; effective January 20, 2020
 - Updated May 27, 2021 for Ceiling Fan Energy Index
 - Became immediately enforceable

U.S. LDCF Regulation

- *Establishment of Energy Standard (Efficiency Requirement)*
 - (10 CFR 430.32(s)(2)). Large-diameter ceiling fans manufactured on or after January 21, 2020, shall have a CFEI greater than or equal to
 - (A) 1.00 at high speed; and
 - (B) 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.

U.S. LDCF Regulation

- *Establishment of Energy Standard (Efficiency Requirement)*

...

- 430.32(s)(2)(ii). 5. Calculation of Ceiling Fan Energy Index (CFEI)

From the Test Results for Large-Diameter Ceiling Fans:

- Calculate CFEI, which is the FEI for large-diameter ceiling fans, at the speeds specified in section 3.5 of this appendix according to ANSI/AMCA 208-18, (incorporated by reference, see § 430.3), with the following modifications:
- (1) Using an Airflow Constant (Q_0) of 26,500 cubic feet per minute;
- (2) Using a Pressure Constant (P_0) of 0.0027 inches water gauge; and
- (3) Using a Fan Efficiency Constant (η_0) of 42 percent.

Canada...

- U.S. Dept. of Energy and Natural Resources Canada (NR Canada) have a working relationship formalized in a memorandum of understanding
- Generally, U.S. appliance/equipment efficiency regulations are adopted into Canadian regulations
- As of July 19, 2021, NR Canada specifies “ceiling fan efficiency” for LDCF, and DOE still defines “ceiling fan efficiency” using cfm/w
 - *Ceiling fan efficiency means the ratio of the total airflow to the total power consumption, in units of cubic feet per minute per watt (CFM/W).*
- Therefore, CFEI not yet applicable to Canadian efficiency regulation

Extract From NR Canada Website

Energy efficiency standard

78 (1) The energy efficiency standard for a ceiling fan is the standard as set out in 10 C.F.R. §430.32(s)(2)(i).

Testing standard

(2) A ceiling fan complies with the energy efficiency standard if it meets that standard when tested in accordance with testing procedures established by 10 C.F.R. Appendix U that are applicable to a ceiling fan as defined in section 75.

Information

79 For the purpose of subsection 5(1) of the Act, the following information must be collected in accordance with 10 C.F.R. Appendix U and provided to the Minister in respect of a ceiling fan:

- (a)** its type;
- (b)** its blade span;
- (c)** its air flow at high speed;
- (d)** its ceiling fan efficiency; and
- (e)** its standby power consumption expressed in watts.





New Metric for LDCF Efficiency Regulations: Ceiling Fan Energy Index (CFEI)

New Metric for LDCF Efficiency Regulations

- Ceiling Fan Energy Index (CFEI)
 - Calculated at two speeds – 100% and 40% of max RPM
 - Intended as a regulatory metric
 - Allows for high utility (airflow) products
 - More difficult to “game” than CFM/W based metrics
 - Very similar to AMCA 208’s FEI, except different constants

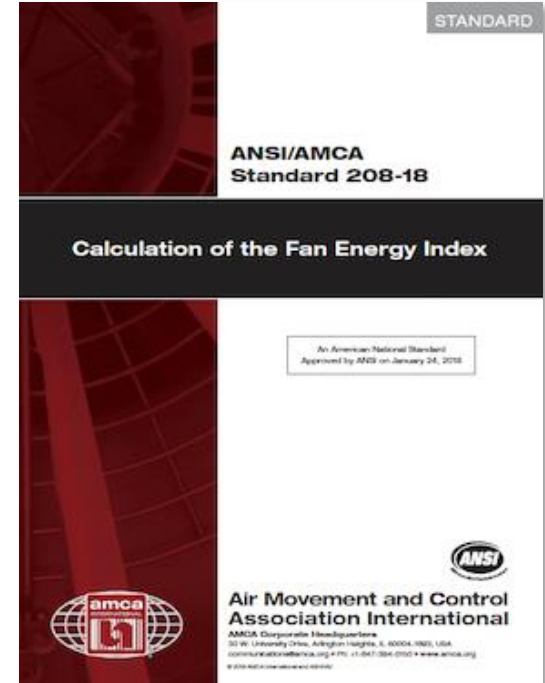
New Metric for LDCF Efficiency Regulations

$$\text{FEI} = \frac{\text{Actual Fan Efficiency}}{\text{Reference Fan Efficiency}} = \frac{\frac{\text{Actual Fan Air Power}}{\text{Actual Fan Electric Power}}}{\frac{\text{Reference Fan Air Power}}{\text{Reference Fan Electric Power}}}$$

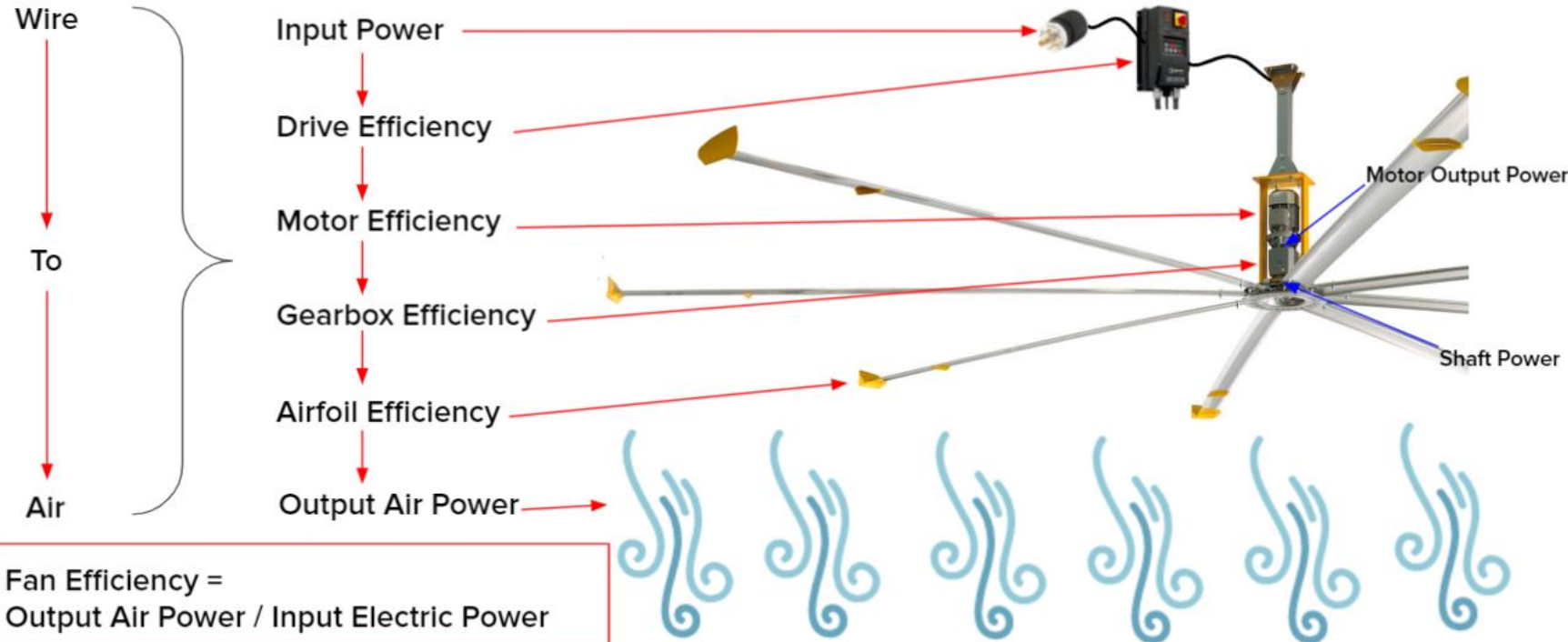
$$\text{FEI} = \frac{\text{Reference Fan Electric Power}}{\text{Actual Fan Electric Power}}$$

How To Calculate CFEI

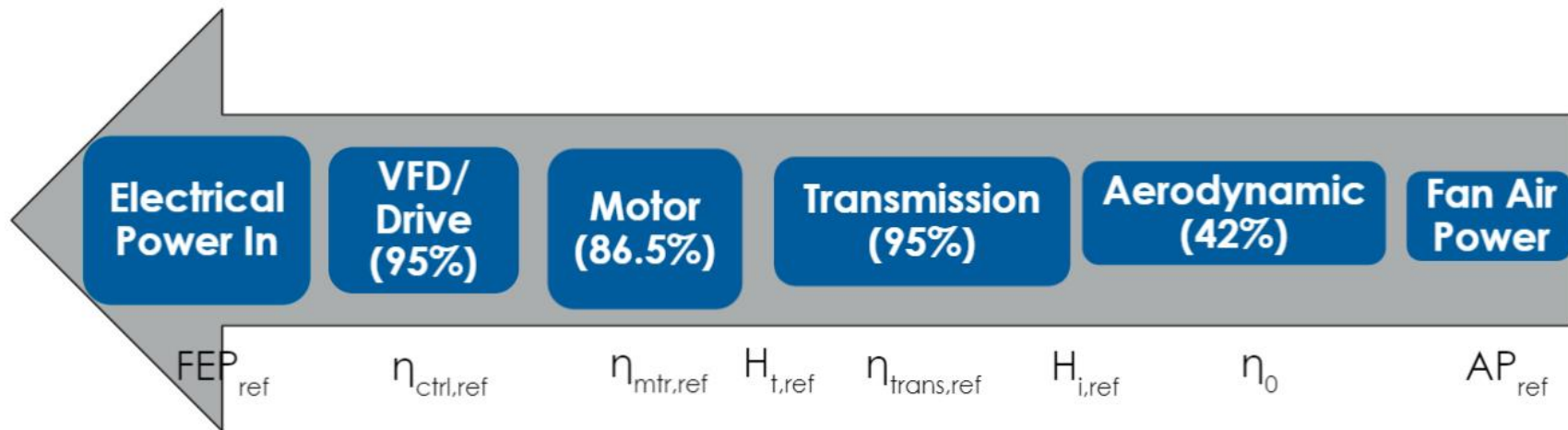
- Use AMCA Standard 208-18
 - FEI equation for total pressure
 - Airflow Constant: $Q_0 = 26,500$ cfm
 - Pressure Constant $P_0 = 0.0027$ in. WG
 - Fan Efficiency Constant $h_0 = 42$ percent
- Metric Equivalents (from AMCA 211 draft)
 - Airflow Constant: $Q_0 = 12.507$ m³/s
 - Pressure Constant $P_0 = 0.6719$ pascals



Ceiling Fan Efficiency - Wire-to-Air



Calculating Reference Fan Electrical Input Power



AP_{ref} = Air power (aka output power)

η_0 = Fan efficiency constant

$H_{i,ref}$ = fan shaft power (ref fan)

$\eta_{trans,ref}$ = transmission efficiency (ref fan)

$H_{t,ref}$ = motor output power (ref fan)

$\eta_{mtr,ref}$ = motor efficiency (ref fan)

$\eta_{ctrl,ref}$ = controller efficiency (ref fan)

FEP_{ref} = Fan electrical input power (ref fan)

Example CFEI – LDCF 100% RPM

- Actual 24' LDCF
 - 235,000 CFM (~600W of Air Power)
 - 1,530 W input power
- Reference 24' LDCF
 - 235,000 CFM
 - 600W Air Power / 42% / 93% / 87% / 100% \cong 1,770 W
 - 1,770 W input power

$$CFEI = 1,770 \text{ W} / 1,530 \text{ W} = 1.16$$

$$CFEI = \frac{FEP_{ref}}{FEP_{actual}}$$

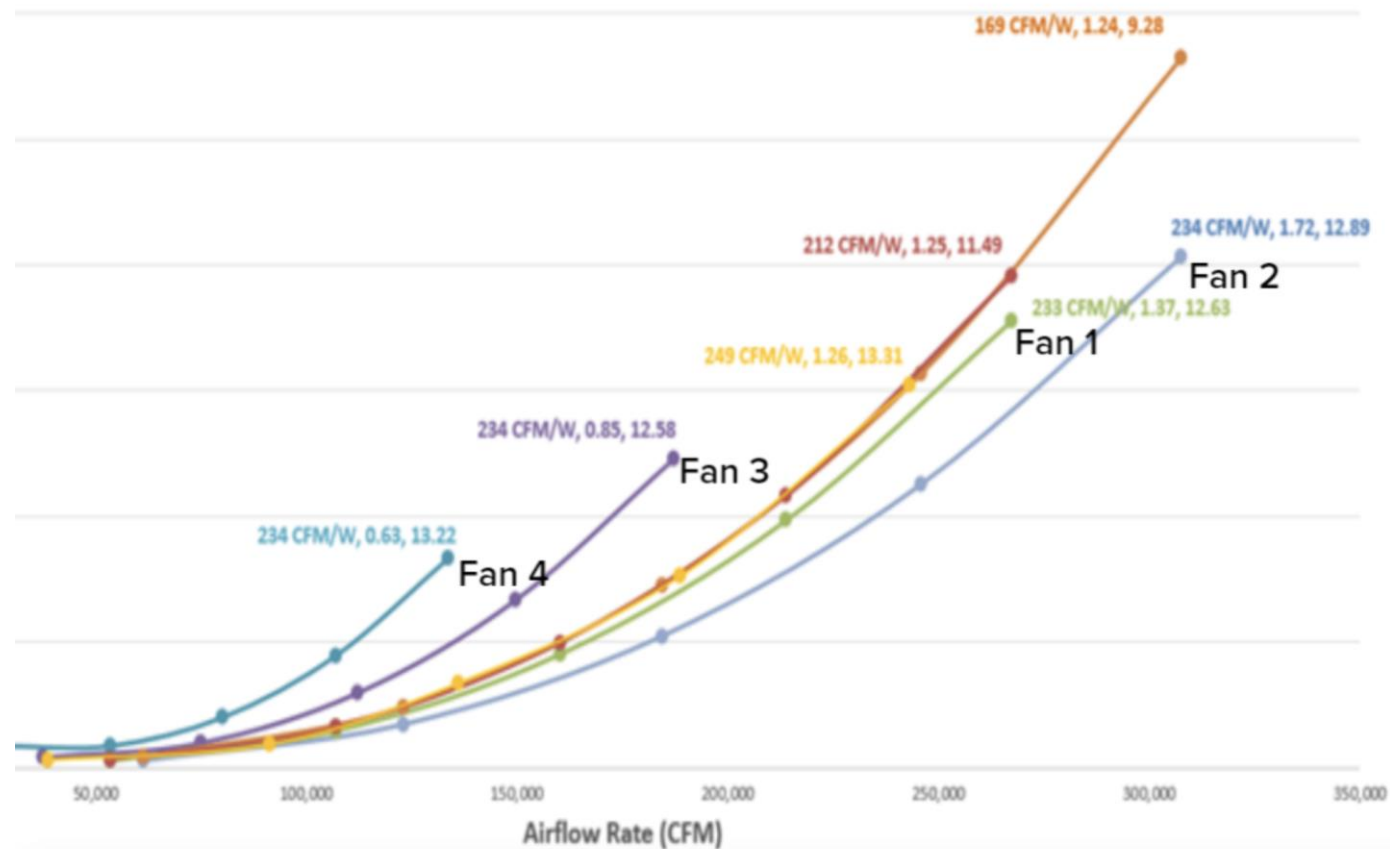
CFEI Calculation – Step by Step

Fan	Fan 1	Variable	
Diameter	24' (288")	-	Measured - 10 CFR 430, App U
Airflow (Act)	235,000 cfm	Q_i	Measured - 10 CFR 430, App U
Input Power (Act)	1,530 W	FEP_{act}	Measured - 10 CFR 430, App U
Total Pressure (Act)	0.0168 in wg	$P_{t,i}$	Calculated - AMCA 208, Eq A.1 IP
Shaft Power (Ref)	1.91 hp	$H_{t,ref}$	Calculated - AMCA 208, Eq 5.3 IP
Trans Effic (Ref)	92.40%	$\eta_{trans,ref}$	Calculated - AMCA 208, Eq 5.5 IP
Motor Output (Ref)	2.07 hp	$H_{t,ref}$	Calculated - AMCA 208, Eq 5.6
Motor Effic (Ref)	87.16%	$\eta_{mtr,ref}$	Calculated - AMCA 208, Eq 5.7 IP
Control Effic (Ref)	100%	$\eta_{ctrl,ref}$	Calculated - AMCA 208, Eq 5.8
Input Power (Ref)	1,772 W	FEP_{ref}	Calculated - AMCA 208, Eq 5.2 IP
$CFEI_{100}$	1.16	$FEI_{t,i}$	Calculated - AMCA 208, Eq 5.1

CFEI Requirements

- Using DOE test procedure (AMCA 230-15), LDCF tested at 100% and 40% speeds only
 - High Speed: 100%
 - At 40% or speed closest to 40% without going under 40%
- Using “modified” AMCA 208-18, calculate CFEI
 - $CFEI \geq 1.00$ at high speed (100%)
 - $CFEI \geq 1.31$ at 40% speed or speed closest to 40% without going lower
- Optional measure standby power
 - Not included in CFEI
 - May be required in future DOE regulations

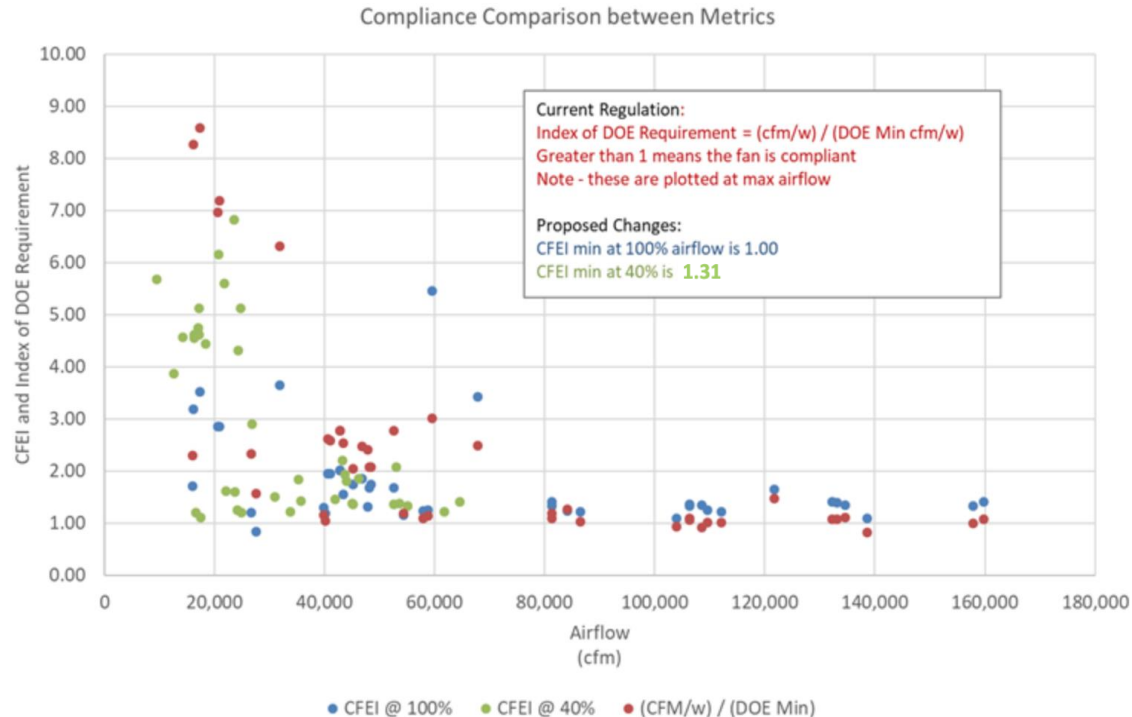
24' Large Diameter Fan - Airflow vs Power



Power vs. Airflow and CFEI

- Previous slide shows input power versus airflow for four fans.
- Fans 1-4 all have the same cfm/W.
- For a given airflow, the lower the curve is on the chart, the more efficient the fan.
- Lowest curve: Fan 2 has a CFEI of 1.72 at 100%
- Highest curve: Fan 4 has a CFEI of 0.63 at 100%.
- Illustrates how a bad fan can pass with cfm/W metric but not with a low CFEI

AMCA Lab Data for LDCF Compliance Rate cfm/Watt vs CFEI



AMCA Lab Data for LDCF Compliance Rate cfm/Watt vs CFEI

- Previous slide shows an index for cfm/W vs. CFEI
- Index (red dots) are very close to 1.00 at highest airflows
 - Below 1.00 is non-compliant
 - Indicates that future fans will have harder time being compliant
 - Blue dots (100% airflow CFEI) at these dots trend higher than 1.00
 - Indicates that CFEI provides cushion for higher-performance/utility fans

CFEI Legislative Timeline

01-21-20	LDCF Federal Rule Enforcement begins
02-05-20	H.R. 5758 introduced by B. Guthrie (R-KY) and J. Schakowski (D-IL) to Congress “Ceiling Fan Improvement Act”
	Vote by House Energy and Commerce Committee
12-09-2020	Vote by Full House
	Received by Senate and Referred to Committee on Energy and Natural Resources
	Omnibus Bill voted by House, included Energy Act 2020, which included Ceiling Fan Improvement Act
	Omnibus Bill voted by Senate
12-27-2020	Omnibus Bill signed by President Donald Trump
05-26-2021	Federal Register publishes Codification

10 CFR 430.32 - Energy and water conservation standards and their compliance dates (5/27/21)

Product class as defined in Appendix U	Minimum efficiency (CFM/W) ¹
Very small-diameter (VSD)	D ≤ 12 in.: 21. D > 12 in.: 3.16 D - 17.04.
Standard	0.65 D + 38.03.
Hugger	0.29 D + 34.46.
High-speed small-diameter (HSSD)	4.16 D + 0.02.

¹ D is the ceiling fan's blade span, in inches, as determined in Appendix U of this part.

(ii) Large-diameter ceiling fans manufactured on or after January 21, 2020, shall have a CFEI greater than or equal to—

(A) 1.00 at high speed; and

(B) 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.



LDCF Testing and Certification

AMCA Certified Ratings Program (CRP)

- AMCA CRP certifies product ratings
 - Including large diameter ceiling fans
- Product certification
 - 6 licensees
 - 15 certified product lines
- Verify at www.amca.org/certify

Find Certified Ratings

1



The screenshot shows the AMCA International Certified Ratings Program website. At the top, there are five circular icons with labels: 'About CRP' (checkmarks), 'Certified Product Search' (magnifying glass), 'Listed Product Search' (gears), 'FEI Finder' (gear with star), and 'Certified Check' (checklist). Below these icons, a paragraph states: 'The AMCA International Certified Ratings Program is a globally recognized third-party program that published data for air movement and control products are accurate.' Underneath is a search bar with the placeholder text 'Search by company name, product type, country, or license type'. Below the search bar, the 'Product Types:' section lists various fan and ventilation products in two columns. A grey arrow points from the 'Large Diameter Ceiling Fan' entry in the second column to the next step.

About CRP Certified Product Search Listed Product Search FEI Finder Certified Check

The AMCA International Certified Ratings Program is a globally recognized third-party program that published data for air movement and control products are accurate.

Search by company name, product type, country, or license type

Product Types:

- Acoustic Duct Silencer
- Agricultural Fan
- Air Circulating Fan
- Air Curtains
- Airflow Measuring Station
- Axial Fan
- Ceiling Ventilator
- Centrifugal Fan
- Damper
- Energy Recovery Ventilator
- Evaporative Cooler
- Induced Flow
- Large Diameter Ceiling Fan
- Louver

2

Large Diameter Ceiling Fan

Certified & listed products by company name.

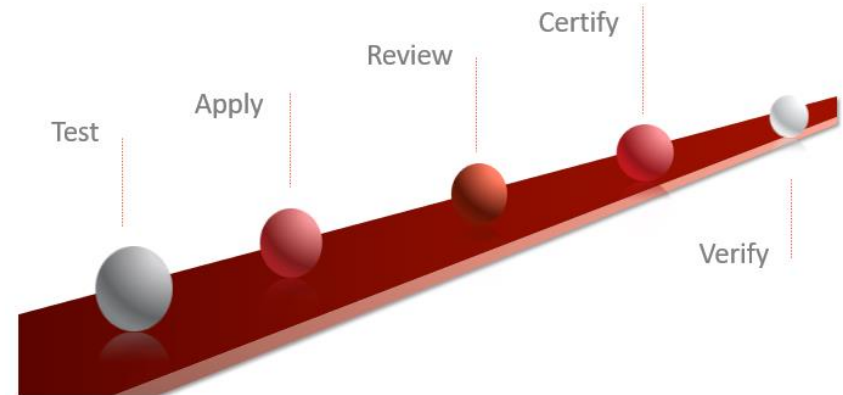
- 4Front Engineered Solutions
- Big Ass Fans
- Greenheck Fan Corporation
- Greenheck India Pvt Ltd
- Hunter Industrial
- Venco

3

Click on company name to access detail

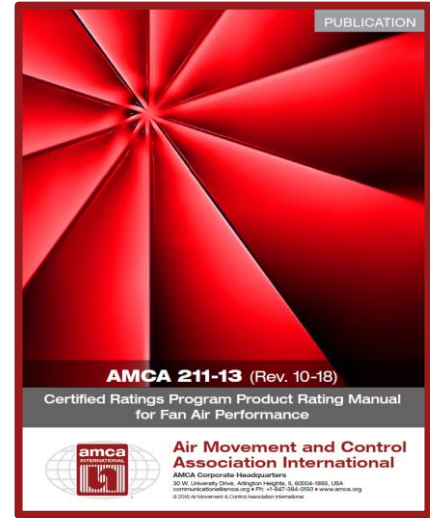
Certification Process

- AMCA HQ tests LDCF
 - AMCA-Accredited Lab
- AMCA issues test reports
- Licensee develops catalogs
- AMCA staff approves catalogs
- Verification test in 3-years



Certification Per AMCA Publication 211

- Operating manual for fan certifications
 - AMCA 211-13 (Rev. 10-18) (i.e., 2018)
 - Volumetric airflow rate
 - Fan system input power, phase, voltage and frequency
 - **Efficacy (volumetric airflow rate/electrical input power)**
 - Nominal impeller speed
 - Direction of operation
 - Available at no cost at www.amca.org/store



Laboratory Test Method

- ANSI/AMCA Standard 230-15 with erratum
 - Erratum published by AMCA May 6, 2021
 - Available at www.amca.org/LDCF
 - Converts electrical input power measurement for standard air density, making ratings independent of test location
- 10 CFR Part 430, Appendix U to Subpart B
- 10 CFR Part 430.32

LDCF Test Method

ANSI/AMCA Standard 230-15

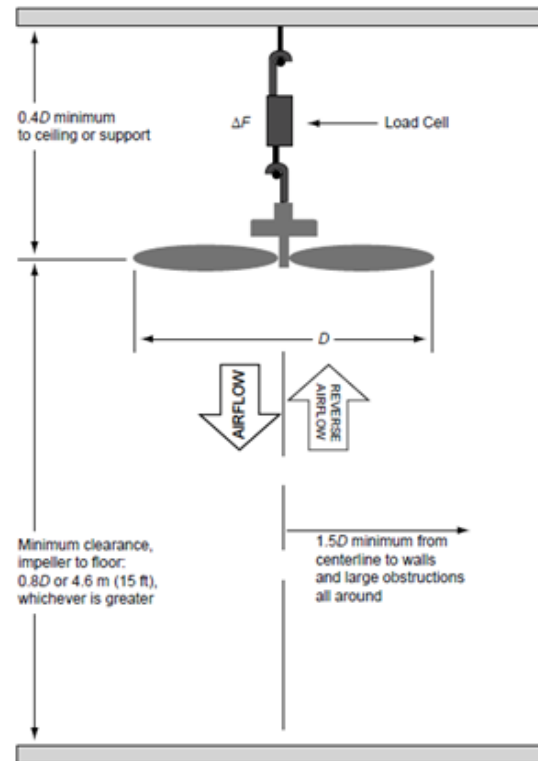
Laboratory Methods of Testing
Air Circulating Fans for Rating
and Certification

An American National Standard
Approved by ANSI on October 16, 2015



**AIR MOVEMENT AND CONTROL
ASSOCIATION INTERNATIONAL INC.**

The International Authority on Air System Components



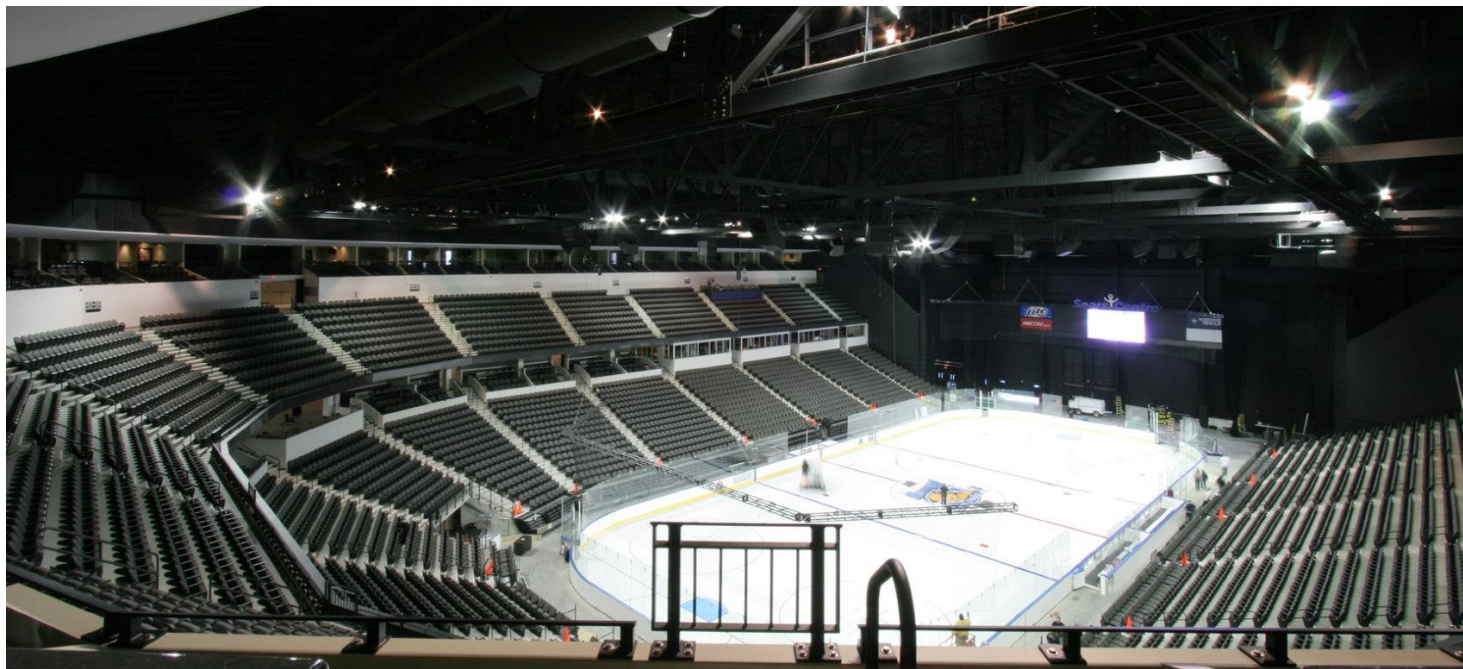
Note:
The vertical centerline through the test setup shall be kept vertical within $\pm 1^\circ$ during testing.

Test Figure 1
Vertical Airflow Setup with Load Cell
(Ceiling Fans)

Where to test?

- Lab accredited by A2LA/ISO 17025
- AMCA HQ Laboratory, Arlington Hts., Illinois
 - Blade spans 7.5-ft (2.3 m) to 18-ft (5.5 m)
- NOW Arena, near Chicago
 - Previously known as Sears Center
 - Blade spans >18-ft (5.5 m)
 - 24-ft (7.3 m) is largest tested
- Manufacturer does not have to be a member to test at AMCA Lab or certify a product

NOW Arena Fan Testing



Where to Find LDCF Regulation Information

- AMCA LDCF Advocacy Web Page
 - www.amca.org/ldcf
- U.S. DOE Appliance and Equipment Standards Program
 - <https://www.energy.gov/eere/buildings/appliance-and-equipment-standards-program>
- DOE Ceiling Fan Regulations (and *listserver* signup)
 - https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=5
- Test Procedure
 - https://www.ecfr.gov/cgi-bin/text-idx?SID=9630460a5b59e8f0b16d3b0411a98094&mc=true&node=ap10.3.430_127.u&rgn=div9
- Energy Standard
 - <https://www.ecfr.gov/cgi-bin/text-idx?rgn=div8&node=10:3.0.1.4.18.3.9.2>
- Compliance database for ceiling fans for filed data:
 - https://www.regulations.doe.gov/certification-data/CCMS-4-Ceiling_Fans
- Canadian ceiling fan efficiency regulation:
 - <https://canadagazette.gc.ca/rp-pr/p2/2019/2019-06-12/html/sor-dors163-eng.html>

Other Resources

- AMCA International: www.amca.org
- AMCA Standards and Publications: www.amca.org/store
- AMCA White Papers: <https://www.amca.org/educate/#articles-and-technical-papers>
- AMCA Webinars (with PDHs): www.amca.org/educate
- AMCA Certified Ratings Program: www.amca.org/certify
- LDCF Testing at AMCA Lab: www.amca.org/test
- AMCA Fan Energy Index (FEI) Microsite: www.amca.org/fei

Thank you for your time!

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NEXT PROGRAM

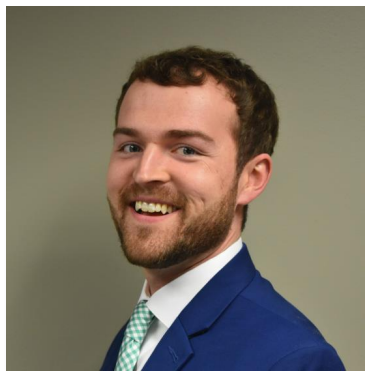
Join us for our next AMCA *insite* Webinar:

- Wednesday, July 28
- 12:00-1:00pm CDT
- ***TOPIC: How to Talk Yourself Into and Out Of Legal Trouble***
- Presenters: Dr. Geoff Sheard, President, AGS Consulting
Paul Juhasz, J.D., Founder and Representative
Attorney, Juhasz Law

>> For additional webinar dates go to: www.amca.org/webinar

Questions?

Presenters



Aaron Gunzner



Michael Ivanovich



Christian Taber



Nazme Mohsina

Bonus Slides

CRP Seal Usage

- Licensee must obtain license from AMCA to use CRP seal
- AMCA CRP seal shall be placed in catalogs, and in software outputs
- Licensee may affix AMCA CRP seal on certified product.



ABC Company certifies that the model Essence shown herein is licensed to bear the AMCA Seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program. The AMCA Certified Ratings Seal applies to air performance ratings only. The AMCA Certified Ratings Seal applies at free delivery only. Performance ratings do not include the effects of appurtenances (accessories).