STANDARD

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Fan System Efficiency and Fan System Input Power Calculation

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Air Movement and Control Association International

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Fan System Efficiency and Fan System Input Power Calculation

1. Purpose

This standard provides a method to estimate the input power and overall efficiency of an extended fan system.

An extended fan system is composed of a fan and an electric motor but may also include a transmission and a motor controller. While direct measurement of fan system performance is preferred, the large number of fan system configurations often makes testing impractical. This standard offers a standardized method to estimate fan system performance by modeling commonly used components. Calculations reported in accordance with this standard offers fan users a tool to compare alternative fan system configurations in a consistent and uniform manner.

This document does not provide selection guidance. Users must assure that selected components have sufficient capacity and are configured to produce the desired results.

2. Scope

The scope of this standard includes all electric motor driven fan systems that use a specific combination of components as defined below:

1. Fan airflow performance tested in accordance with ANSI/AMCA Standard 210 [1] ANSI/AMCA Standard 230 [2], ANSI/AMCA Standard 260 [3] or ISO Standard 5801 [4] or rated in accordance with AMCA Publication 211 [5].
2. Polyphase induction motors within the scope of EPCA [6], IEC 60034-30-1 [7], or GB 18613 [8]. Other types of motors are explicitly excluded.
3. Pulse-width modulated variable frequency drives (VFDs).
4. Mechanical power transmissions that use V-belts, synchronous belts, or flexible couplings.

3. Definitions and Symbols

For the purpose of this standard, the definitions, units of measure and symbols in this section apply.

Definitions for fan pressures and efficiencies are found in the standards referenced in Section 2.

3.1 Definitions

3.1.1 Fan system
A fan product that includes all appurtenances, accessories, motors, drives and controllers necessary or applied to the fan.

3.1.2 V-belt power transmission
Drive belts having a substantially trapezoidal cross section that uses sheaves (pulleys) having smooth contact surfaces. Conventional V-belts have a constant cross section along their length, while notched V-belts (also known as cogged V-belts) have slots running perpendicular to their length. The slots reduce bending resistance and offer improved efficiency over conventional V-belts. This standard does not account for this improved efficiency.

3.1.3 Synchronous belt power transmission
Drive belts having a substantially rectangular cross section that contains teeth that engage corresponding teeth on the sheaves (pulleys) resulting in no-slip power transmission. These belts are sometimes called timing or toothed belts.

3.1.4 Flexible coupling power transmission

A coupling that is used to transmit torque from one shaft to another in a coaxial configuration where the two shafts are at the same speed. A flexible coupling allows for minor shaft misalignment.

3.2 Symbols

Symbol	Description	SI Unit	I-P Unit
η_B	Transmission efficiency	dimensionless	
η_e	Overall fan system total efficiency	dimensionless	
η_{es}	Overall fan system static efficiency	dimensionless	
η_m	Motor efficiency		
η_{mc}	Combined motor control and motor efficiency	dimensionless	
η_R	Nominal regulated motor efficiency	dimensionless	
η_S	Fan static efficiency	dimensionless	
η_T	Fan total efficiency	dimensionless	
H_{co}	Output capacity of VFD	kW	hp
H_i	Fan input power	kW	hp
H_m	Motor output power	kW	hp
H_{mo}	Motor nameplate output power	kW	hp
L_c	Motor controller load ratio	dimensionless	
L_m	Motor load ratio	dimensionless	
N	Fan speed	rpm	rpm
W_c	Fan system input power*	kW	kW
n	Number of motor poles	dimensionless	
n_m	Number of motors controlled by the VFD	dimensionless	

* Fan system input power, equivalent to motor controller input power or motor input power, depending on system configuration

4. Fan System Energy Calculations (General)

This section describes the calculations required to estimate the extended fan system input power and extended fan system efficiency. Calculations start with the fan performance and then progress through each fan system component.

4.1 Components

4.1.1 Fan

Fan input power, H_i, is the starting point for the system calculation. Fan performance shall be determined in accordance with an accepted performance standard such as ANSI/AMCA Standard 210, ANSI/AMCA Standard 230, ANSI/AMCA Standard 260 or ISO 5801. The fan laws shall be used to determine fan performance at operating conditions other than those tested. For calculation of the fan system input power (W_c), the following performance variables must be available for the desired fan operating point:

H_i Fan input (shaft) power in kW (hp)

To calculate the overall fan system efficiency, the following must also be available:

η_s Fan static efficiency

or

η_T Fan total efficiency

4.1.2 Power transmission
The power transmission is a component of the fan system that transfers power from the motor to the fan, most often involving a speed change. The transmission is not present in direct drive configurations where the motor is directly coupled to the fan shaft or impeller.

4.1.2.1 V-belt power transmission
The efficiency of a V-belt transmission is calculated as

$$\eta_B = 0.96\left(\frac{H_i}{H_i+1.64}\right)^{0.05} \quad \text{SI}$$

$$\eta_B = 0.96\left(\frac{H_i}{H_i+2.2}\right)^{0.05} \quad \text{I-P}$$

4.1.2.2 Synchronous belt power transmission
The efficiency of a synchronous belt transmission is calculated as

$$H_i \leq 1\ kW, \eta_B = 0.94$$

$$1\ kW < H_i \leq 5\ kW, \eta_B = 0.01\ H_i + 0.93 \quad \text{SI}$$

$$H_i > 5\ kW, \eta_B = 0.98$$

or

$$H_i \leq 1.34\ hp, \eta_B = 0.94$$

$$1.34\ hp < H_i \leq 6.7\ hp, \eta_B = 0.00746\ H_i + 0.93 \quad \text{I-P}$$

$$H_i > 6.7\ hp, \eta_B = 0.98$$

4.1.2.3 Flexible coupling power transmission
The efficiency of a flexible shaft coupling is

$\eta_B = 0.98$

4.1.2.4 No power transmission
If the motor shaft is rigidly connected to the fan impeller, then

$$\eta_B = 1$$

4.1.3 Motor and controller
The following sections detail the calculations for various motor and motor/controller combinations. Fan systems incorporating components other than those described here are not covered by this standard.

4.1.3.1 Regulated polyphase induction motors controlled by a VFD

Calculations presented here are limited to certain regulated polyphase induction motors driven by pulse-width modulated VFDs. Applicable motors include those regulated within the scope of EPCA, IEC 60034-30 or GB 18613.

The following motor and VFD parameters must be known:

H_{mo}	Motor nameplate output power
n	Number of motor poles
TEFC or ODP	Motor enclosure
H_{co}	VFD output capacity

The motor and variable frequency drive efficiencies are combined into a single value. For purposes of this standard, the output capacity of the VFD is defined as the largest motor the VFD is capable of driving. VFD output capacity will generally match the rated output power of the motor ($H_{co} = H_{mo}$). The calculation allows for a VFD with output capacity greater than that of the driven motor (e.g., a 7.5 hp capacity VFD driving a 5 hp motor). This accommodates a situation in which the driven motor is operated at a load ratio greater than one.

These calculations assume that the VFD is operating with a constant V/Hz output, and they should result in a conservative estimate. There are other algorithms that can result in lower input power.

The motor output power at the fan operating point is calculated by

$$H_m = \frac{H_i}{\eta_B}$$

where H_i is the fan input power and η_B is the transmission efficiency calculated from Section 4.1.2.

The combined motor and VFD efficiency is calculated in the following steps. First, the motor efficiency is calculated as

$$\eta_m = \eta_R \left(\frac{aL_m}{b + L_m} + cL_m^2\right)$$

where η_B is the nominal motor efficiency obtained from Table A1 (EPCA), Table A2 (IEC 63034-30-1) or Table A3 (GB 18613), depending on the applicable motor configuration. L_m is the motor load ratio calculated by

$$L_m = \frac{H_m}{H_{mo}} \qquad [0 < L_m < 1.5]$$

and

a and *b* are motor coefficients obtained from Table B1 (motor output power rating in hp) or Table B2 (motor output power rating in kW), depending on the applicable motor configuration. The coefficient *c* is calculated as

$$c = 1 - \frac{a}{b + 1}$$

The VFD load ratio is based on the required VFD output (motor input) and is calculated as

$$L_c = \frac{H_m}{\eta_m H_{co}}$$

where H_{co} is the output capacity of the VFD.

The combined motor and VFD efficiency is calculated by

$$\eta_{mc} = \eta_m \left(\frac{dL_c}{e + L_c} + fL_c\right)$$

The coefficients *d, e* and *f* are found in Table C1 (hp) or Table C2 (kW) for the appropriate VFD capacity.

In situations where a single VFD is used to control several identical motors operating in parallel, the load ratio for the VFD is replaced by

$$\mathrm{L_c} = \mathrm{n_m} \frac{\mathrm{H_m}}{\eta_\mathrm{m} \mathrm{H_{co}}}$$

where n_m is the number of motors controlled by the VFD.

Advisory note: The VFD and motor models used for this calculation are based on constant V/Hz operation and pure sine wave power. In practice, other control settings are sometimes adopted to improve energy efficiency or to better match VFD output to actual fan operating conditions. This document does not provide selection guidance. Users must assure that selected components have sufficient capacity and are configured to produce the desired results. The purpose here is to provide a consistent calculation procedure for comparing multiple fan systems when actual test data are not available. The output capacity of the VFD must equal or exceed the required input to the motor.

4.1.3.2 Regulated polyphase induction motors powered DOL (Direct on line)
Calculations presented here are limited to certain regulated polyphase induction motors directly driven from the line voltage and line frequency. Applicable motors include those regulated within the scope of EPCA, IEC 60034-30 or GB 18613.

The following motor and component parameters must be known:

H_{mo}	Motor nameplate output power
n	Number of motor poles
TEFC or ODP	Motor enclosure

TEAO motors are not covered by this standard.

The motor output power at the fan operating point is calculated by

$$H_m = \frac{H_i}{\eta_B}$$

The motor efficiency is calculated by

$$\eta_m = \eta_R \left(\frac{aL_m}{b + L_m} + cL_m^2\right)$$

where

η_R is the nominal motor efficiency obtained from Table A1 (EPCA), Table A2 (IEC 60034-30) or Table A3 (GB- 18613), depending on the applicable motor configuration and regulatory jurisdiction. L_m is the motor load ratio calculated by

$L_m = \frac{H_m}{H_{mo}}$ $[0 < L_m < 1.5]$

a and *b* are coefficients obtained from Table D1 (hp rated motors) or Table D2 (kW rated motors), depending on the applicable motor configuration. The coefficient *c* is calculated as

$$c = 1 - \frac{a}{b+1}$$

Advisory note: Calculations at motor load ratios greater than one (motor service factor) are permitted up to L_m = 1.5. Users must assure that specific motors are capable of operation at a load ratio greater than 1.0.

4.2 System integration

Overall fan system power input and efficiency are determined by combining results for the fan system components. The fan system input power in kW for DOL motor operation is calculated by

$$W_c = \frac{H_i}{\eta_m \eta_B}$$ SI

$$W_c = \frac{0.746\, H_i}{\eta_m \eta_B}$$ I-P

The fan system input power in kW for combined motor and VFD operation is calculated by

$$W_c = \frac{H_i}{\eta_{mc} \eta_B}$$ SI

$$W_c = \frac{0.746 H_i}{\eta_{mc} \eta_B}$$ I-P

The overall fan system efficiency (wire to air) for DOL motor operation is calculated by

$$\eta_e = \eta_T \eta_B \eta_m$$

or

$$\eta_{es} = \eta_s \eta_B \eta_m$$

The overall fan system efficiency (wire to air) for combined motor and VFD operation is calculated by

$$\eta_e = \eta_T \eta_B \eta_{mc}$$

or

$$\eta_{es} = \eta_s \eta_B \eta_{mc}$$

Scaling of these results using the fan laws is not permitted.

5. Reporting of Results

Reporting fan system input power or overall fan system efficiency must include the following information:

1. Overall fan system efficiency rounded to the nearest integer or fan system input power
2. Fan operating point
    a. flow
    b. fan pressure (total or static)
    c. shaft power
    d. fan speed
    e. inlet density
    f. test standard used to obtain items a, b, c
    g. fan system input power
3. Motor nameplate power, number of poles (or synchronous speed), enclosure, full load motor efficiency
4. VFD nameplate capacity
5. Input power line frequency
6. Transmission type (V-belt, synchronous belt, flexible coupling or none)

Annex A

Motor Efficiencies (Normative)

Table A1. EPCA Nominal Motor Efficiency (60 Hz motors)

Motor Power/Standard Kilowatt Equivalent	ODP				TEFC			
	2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	4 POLE	6 POLE	8 POLE
1/.75	77.0	85.5	82.5	75.5	77.0	85.5	82.5	72.0
1.5/1.1	84.0	86.5	86.5	77.0	84.0	86.5	87.5	75.5
2/1.5	85.5	86.5	87.5	86.5	85.5	86.5	88.5	81.5
3/2.2	85.5	89.5	88.5	87.5	86.5	89.5	89.5	82.5
5/3.7	86.5	89.5	89.5	88.5	88.5	89.5	89.5	84.0
7.5/5.5	88.5	91.0	90.2	89.5	89.5	91.7	91.0	84.0
10/7.5	89.5	91.7	91.7	90.2	90.2	91.7	91.0	87.5
15/11	90.2	93.0	91.7	90.2	91.0	92.4	91.7	87.5
20/15	91.0	93.0	92.4	91.0	91.0	93.0	91.7	88.5
25/18.5	91.7	93.6	93.0	91.0	91.7	93.6	93.0	88.5
30/22	91.7	94.1	93.6	91.7	91.7	93.6	93.0	90.2
40/30	92.4	94.1	94.1	91.7	92.4	94.1	94.1	90.2
50/37	93.0	94.5	94.1	92.4	93.0	94.5	94.1	91.0
60/45	93.6	95.0	94.5	93.0	93.6	95.0	94.5	91.0
75/55	93.6	95.0	94.5	94.1	93.6	95.4	94.5	92.4
100/75	93.6	95.4	95.0	94.1	94.1	95.4	95.0	92.4
125/90	94.1	95.4	95.0	94.1	95.0	95.4	95.0	93.0
150/110	94.1	95.8	95.4	94.1	95.0	95.8	95.8	93.0
200/150	95.0	95.8	95.4	94.1	95.4	96.2	95.8	93.6
250/186	95.0	95.8	95.4	95.0	95.8	96.2	95.8	94.1
300/224	95.4	95.8			95.8	96.2		
350/261	95.4	95.8			95.8	96.2		
400/298	95.8	95.8			95.8	96.2		
450/336	95.8	96.2			95.8	96.2		
500/373	95.8	96.2			95.8	96.2		

Reference: NEMA MG-1, Table 12-12

Table A2.a IEC 60034-30-1 Nominal Motor Efficiency 50 Hz

Motor Power (kW)	IE1				IE2				IE3			
	2 Pole	4 Pole	6 Pole	8 Pole	2 Pole	4 Pole	6 Pole	8 Pole	2 Pole	4 Pole	6 Pole	8 Pole
1.1	75.0	75.0	72.9	66.5	79.6	81.4	78.1	70.8	82.7	84.1	81.0	77.7
1.5	77.2	77.2	75.2	70.2	81.3	82.8	79.8	74.1	84.2	85.3	82.5	79.7
2.2	79.7	79.7	77.7	74.2	83.2	84.3	81.8	77.6	85.9	86.7	84.3	81.9
3	81.5	81.5	79.7	77.0	84.6	85.5	83.3	80.0	87.1	87.7	85.6	83.5
4	83.1	83.1	81.4	79.2	85.8	86.6	84.6	81.9	88.1	88.6	86.8	84.8
5.5	84.7	84.7	83.1	81.4	87.0	87.7	86.0	83.8	89.2	89.6	88.0	86.2
7.5	86.0	86.0	84.7	83.1	88.1	88.7	87.2	85.3	90.1	90.4	89.1	87.3
11	87.6	87.6	86.8	85.0	89.4	89.8	88.7	86.9	91.2	91.4	90.3	88.6
15	88.7	88.7	87.7	86.2	90.3	90.6	89.7	88.0	91.9	92.1	91.2	89.6
18.5	89.3	89.3	88.6	86.9	90.9	91.2	90.4	88.6	92.4	92.6	91.7	90.1
22	89.9	89.9	89.2	87.4	91.3	91.6	90.9	89.1	92.7	93.0	92.2	90.6
30	90.7	90.7	90.2	88.3	92.0	92.3	91.7	89.8	93.3	93.6	92.9	91.3
37	91.2	91.2	90.8	88.8	92.5	92.7	92.2	90.3	93.7	93.9	93.3	91.8
45	91.7	91.7	91.4	89.2	92.9	93.1	92.7	90.7	94.0	94.2	93.7	92.2
55	92.1	92.1	91.9	89.7	93.2	93.5	93.1	91.0	94.3	94.6	94.1	92.5
75	92.7	92.7	92.6	90.3	93.8	94.0	93.7	91.6	94.7	95.0	94.6	93.1
90	93.0	93.0	92.9	90.7	94.1	94.2	94.0	91.9	95.0	95.2	94.9	93.4
110	93.3	93.3	93.3	91.1	94.3	94.5	94.3	92.3	95.2	95.4	95.1	93.7
132	93.5	93.5	93.5	91.5	94.6	94.7	94.6	92.6	95.4	95.6	95.4	94.0
160	93.8	93.8	93.8	91.9	94.8	94.9	94.8	93.0	95.6	95.8	95.6	94.3
200	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6
250	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6
315	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6
355	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6
400	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6
450	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6
500 up to 1000	94.0	94.0	94.0	92.5	95.0	95.1	95.0	93.5	95.8	96.0	95.8	94.6

Table A2.b IEC 60034-30-1 Nominal Motor Efficiency 60 Hz

Motor Power (kW)	IE1				IE2				IE3			
	2 Pole	4 Pole	6 Pole	8 Pole	2 Pole	4 Pole	6 Pole	8 Pole	2 Pole	4 Pole	6 Pole	8 Pole
1.1	78.5	79.0	75.0	73.5	82.5	84.0	85.5	75.5	84.0	86.5	87.5	78.5
1.5	81.0	81.5	77.0	77.0	84.0	84.0	86.5	82.5	85.5	86.5	88.5	84.0
2.2	81.5	83.0	78.5	78.0	85.5	87.5	87.5	84.0	86.5	89.5	89.5	85.5
3.7	84.5	85.0	83.5	80.0	87.5	87.5	87.5	85.5	88.5	89.5	89.5	86.5
5.5	86.0	87.0	85.0	84.0	88.5	89.5	89.5	85.5	89.5	91.7	91.0	86.5
7.5	87.5	87.5	86.0	85.0	89.5	89.5	89.5	88.5	90.2	91.7	91.0	89.5
11	87.5	88.5	89.0	87.5	90.2	91.0	90.2	88.5	91.0	92.4	91.7	89.5
15	88.5	89.5	89.5	88.5	90.2	91.0	90.2	89.5	91.0	93.0	91.7	90.2
18.5	89.5	90.5	90.2	88.5	91.0	92.4	91.7	89.5	91.7	93.6	93.0	90.2
22	89.5	91.0	91.0	90.2	91.0	92.4	91.7	91.0	91.7	93.6	93.0	91.7
30	90.2	91.7	91.7	90.2	91.7	93.0	93.0	91.0	92.4	94.1	94.1	91.7
37	91.5	92.4	91.7	91.0	92.4	93.0	93.0	91.7	93.0	94.5	94.1	92.4
45	91.7	93.0	91.7	91.0	93.0	93.6	93.6	91.7	93.6	95.0	94.5	92.4
55	92.4	93.0	92.1	91.5	93.0	94.1	93.6	93.0	93.6	95.4	94.5	93.6
75	93.0	93.2	93.0	92.0	93.6	94.5	94.1	93.0	94.1	95.4	95.0	93.6
90	93.0	93.2	93.0	92.5	94.5	94.5	94.1	93.6	95.0	95.4	95.0	94.1
110	93.0	93.5	94.1	92.5	94.5	95.0	95.0	93.6	95.0	95.8	95.8	94.1
150	94.1	94.5	94.1	92.5	95.0	95.0	95.0	93.6	95.4	96.2	95.8	94.5
185	94.1	94.5	94.1	92.5	95.4	95.0	95.0	93.6	95.8	96.2	95.8	95.0
220 up to 335	94.1	94.5	94.1	92.5	95.4	95.4	95.0	93.6	95.8	96.2	95.8	95.0
375 up to 1,000	94.1	94.5	94.1	92.5	95.4	95.8	95.0	94.1	95.8	96.2	95.8	95.0

Table A3. GB 18613 – 2012 Nominal Motor Efficiency

Motor Power (kW)	Grade 1			Grade 2			Grade 3		
	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole
1	84.9	85.6	83.1	80.7	82.5	78.9	77.4	79.6	75.9
1.1	86.7	87.4	84.1	82.7	84.1	81.0	79.6	81.4	78.1
1.5	87.5	88.1	86.2	84.2	85.3	82.5	81.3	82.8	79.8
2.2	89.1	89.7	87.1	85.9	86.7	84.3	83.2	84.3	81.8
3	89.7	90.3	88.7	87.1	87.7	85.6	84.6	85.5	83.3
4	90.3	90.9	89.7	88.1	88.6	86.8	85.8	86.6	84.6
5.5	91.5	92.1	89.5	89.2	89.6	88.0	87.0	87.7	86.0
7.5	92.1	92.6	90.2	90.1	90.4	89.1	88.1	88.7	87.2
11	93.0	93.6	91.5	91.2	91.4	90.3	89.4	89.8	88.7
15	93.4	94.0	92.5	91.9	92.1	91.2	90.3	90.6	89.7
18.5	93.8	94.3	93.1	92.4	92.6	91.7	90.9	91.2	90.4
22	94.4	94.7	93.9	92.7	93.0	92.2	91.3	91.6	90.9
30	94.5	95.0	94.3	93.3	93.6	92.9	92.0	92.3	91.7
37	94.8	95.3	94.6	93.7	93.9	93.3	92.5	92.7	92.2
45	95.1	95.6	94.9	94.0	94.2	93.7	92.9	93.1	92.7
55	95.4	95.8	95.2	94.3	94.6	94.1	93.2	93.5	93.1
75	95.6	96.0	95.4	94.7	95.0	94.6	93.8	94.0	93.7
90	95.8	96.2	95.6	95.0	95.2	94.9	94.1	94.2	94.0
110	96.0	96.4	95.6	95.2	95.4	95.1	94.6	94.5	94.3
132	95.0	96.5	95.8	95.4	95.6	95.4	94.6	94.7	94.6
160	96.2	96.5	96.0	95.6	95.8	95.6	94.8	94.9	94.8
200	96.3	96.6	96.1	95.8	96.0	95.8	95.0	95.1	95.0
250	96.4	96.7	96.1	95.8	96.0	95.8	95.0	95.1	95.0
315	96.5	96.8	96.1	95.8	96.0	95.8	95.0	95.1	95.0
355	96.6	96.8	96.1	95.8	96.0	95.8	95.0	95.1	95.0
375	96.6	96.8	96.1	95.8	96.0	95.8	95.0	95.1	95.0

Annex B

Motor (with VFD) Performance Constants (Normative)

Table B1. Polyphase Induction Motor Performance Constants (hp rated motors with VFD)

HP	2 POLE		4 POLE		6 & 8 POLE	
	a	***b***	***a***	***b***	***a***	***b***
1	1.02906	0.01701	1.03744	0.03337	1.09059	0.06457
1.5	1.02998	0.01610	1.03812	0.03120	1.08484	0.05903
2	1.03090	0.01520	1.03880	0.02902	1.07910	0.05349
3	1.03273	0.01338	1.04016	0.02467	1.06760	0.04240
5	1.03641	0.00975	1.04288	0.01596	1.04461	0.02024
7.5	1.03489	0.00892	1.04077	0.01446	1.04243	0.01798
10	1.03338	0.00808	1.03866	0.01296	1.04025	0.01572
15	1.03035	0.00641	1.03443	0.00996	1.03588	0.01121
20	1.02732	0.00474	1.03021	0.00696	1.03152	0.00670
25	1.02654	0.00476	1.02882	0.00642	1.02977	0.00622
30	1.02575	0.00478	1.02742	0.00588	1.02803	0.00575
40	1.02418	0.00481	1.02464	0.00479	1.02454	0.00480
50	1.02261	0.00485	1.02185	0.00370	1.02106	0.00384
60	1.02226	0.00449	1.02100	0.00350	1.02057	0.00399
75	1.02174	0.00395	1.01972	0.00320	1.01985	0.00420
100	1.02087	0.00306	1.01758	0.00269	1.01864	0.00455
125	1.01997	0.00299	1.01725	0.00286	1.01956	0.00459
150	1.01907	0.00293	1.01692	0.00303	1.02047	0.00462
200	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
250	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
300	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
350	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
400	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
450	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
500	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468

Table B2. Polyphase Induction Motor Performance Constants (kW rated motors with VFD)

kW	2 POLE		4 POLE		6 & 8 POLE	
	a	***b***	***a***	***b***	***a***	***b***
1	1.02968	0.01639	1.03791	0.03189	1.08668	0.06080
1.1	1.02993	0.01615	1.03809	0.03131	1.08514	0.05931
1.5	1.03092	0.01518	1.03882	0.02897	1.07897	0.05337
2.2	1.03264	0.01347	1.04009	0.02489	1.06819	0.04297
3	1.03461	0.01153	1.04155	0.02022	1.05586	0.03108
3.7	1.03633	0.00982	1.04283	0.01614	1.04507	0.02068
4	1.03619	0.00963	1.04257	0.01575	1.04430	0.01991
5.5	1.03497	0.00896	1.04088	0.01454	1.04254	0.01810
7.5	1.03335	0.00806	1.03861	0.01293	1.04020	0.01568
11	1.03050	0.00650	1.03465	0.01012	1.03610	0.01144
15	1.02731	0.00474	1.03018	0.00695	1.03148	0.00669
18.5	1.02657	0.00476	1.02887	0.00644	1.02984	0.00624
22	1.02583	0.00477	1.02756	0.00593	1.02821	0.00580
30	1.02414	0.00481	1.02458	0.00477	1.02447	0.00478
37	1.02267	0.00485	1.02196	0.00375	1.02120	0.00388
45	1.02225	0.00448	1.02097	0.00349	1.02056	0.00399
55	1.02178	0.00400	1.01983	0.00322	1.01991	0.00418
75	1.02085	0.00305	1.01758	0.00269	1.01866	0.00455
90	1.02013	0.00300	1.01731	0.00283	1.01940	0.00458
110	1.01916	0.00294	1.01695	0.00301	1.02038	0.00461
132	1.01810	0.00286	1.01656	0.00321	1.02146	0.00465
150	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
160	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
185	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
200	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
220	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
250	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
300	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
330	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
375	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468

Annex C
Variable Frequency Drive (VFD) Performance Constants (Normative)

C1. VFD Performance Constants (hp capacity)

HP	***d***	***e***	***f***
1	0.98030	0.04000	-0.01310
1.5	0.97995	0.03855	-0.01180
2	0.97960	0.03710	-0.01050
3	0.97890	0.03420	-0.00790
5	0.97750	0.02840	-0.00270
7.5	0.97810	0.02530	-0.00040
10	0.97870	0.02220	0.00190
15	0.98185	0.01985	0.00070
20	0.98500	0.01750	-0.00050
25	0.98620	0.01650	-0.00320
30	0.98740	0.01550	-0.00590
40	0.98765	0.01695	-0.00380
50	0.98790	0.01840	-0.00170
60	0.97190	0.01450	0.01180
75	0.99190	0.01790	-0.00130
100	0.98240	0.01260	0.00140
125	0.98293	0.01190	-0.00010
150	0.98345	0.01120	-0.00160
200	0.98450	0.00980	-0.00460
250	0.98450	0.00980	-0.00460
300	0.98450	0.00980	-0.00460
350	0.98450	0.00980	-0.00460
400	0.98450	0.00980	-0.00460
450	0.98450	0.00980	-0.00460
500	0.98450	0.00980	-0.00460

C2. VFD Performance Constants (kW capacity)

kW	*d*	*e*	*f*
1	0.98006	0.03901	-0.01221
1.1	0.97997	0.03862	-0.01187
1.5	0.97959	0.03707	-0.01047
2.2	0.97894	0.03435	-0.00803
3	0.97818	0.03124	-0.00524
3.7	0.97753	0.02852	-0.00280
4	0.97759	0.02795	-0.00237
5.5	0.97807	0.02546	-0.00052
7.5	0.97873	0.02217	0.00189
11	0.98169	0.01997	0.00076
15	0.98503	0.01748	-0.00056
18.5	0.98615	0.01654	-0.00309
22	0.98728	0.01560	-0.00562
30	0.98766	0.01698	-0.00375
37	0.98789	0.01834	-0.00178
45	0.97233	0.01457	0.01152
55	0.99020	0.01761	-0.00019
75	0.98241	0.01258	0.00137
90	0.98283	0.01202	0.00016
110	0.98340	0.01127	-0.00145
132	0.98402	0.01045	-0.00322
150	0.98450	0.00980	-0.00460
160	0.98450	0.00980	-0.00460
185	0.98450	0.00980	-0.00460
200	0.98450	0.00980	-0.00460
220	0.98450	0.00980	-0.00460
250	0.98450	0.00980	-0.00460
300	0.98450	0.00980	-0.00460
330	0.98450	0.00980	-0.00460
375	0.98450	0.00980	-0.00460

Annex D
Motor (DOL) Performance Constants (Normative)

Table D1. Polyphase Induction Motor Performance Constants (DOL, hp rated motors)

HP	2 POLE		4 POLE		6 & 8 POLE	
	a	*b*	*a*	*b*	*a*	*b*
1	1.13460	0.08674	1.12541	0.09132	1.16873	0.11466
1.5	1.12932	0.08114	1.12067	0.08492	1.15895	0.10606
2	1.12405	0.07555	1.11592	0.07851	1.14917	0.09747
3	1.11350	0.06436	1.10643	0.06571	1.12962	0.08027
5	1.09241	0.04197	1.08745	0.04009	1.09051	0.04588
7.5	1.08883	0.03990	1.08340	0.03745	1.08579	0.04217
10	1.08526	0.03783	1.07936	0.03481	1.08107	0.03846
15	1.07811	0.03368	1.07127	0.02953	1.07163	0.03104
20	1.07096	0.02953	1.06318	0.02425	1.06218	0.02362
25	1.06949	0.02923	1.06033	0.02291	1.05966	0.02257
30	1.06802	0.02892	1.05749	0.02157	1.05713	0.02152
40	1.06508	0.02831	1.05180	0.01889	1.05208	0.01942
50	1.06214	0.02769	1.04612	0.01621	1.04703	0.01732
60	1.05946	0.02585	1.04436	0.01556	1.04553	0.01691
75	1.05544	0.02309	1.04172	0.01459	1.04328	0.01631
100	1.04874	0.01849	1.03732	0.01298	1.03954	0.01530
125	1.04713	0.01813	1.03731	0.01332	1.03948	0.01463
150	1.04553	0.01778	1.03729	0.01365	1.03942	0.01396
200	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
250	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
300	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
350	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
400	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
450	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
500	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262

Table D2. Polyphase Induction Motor Performance Constants (DOL, kW rated motors)

	2 POLE		4 POLE		6 & 8 POLE	
kW	a	b	a	b	a	b
1	1.13101	0.08293	1.12218	0.08696	1.16207	0.10881
1.1	1.12959	0.08143	1.12091	0.08524	1.15945	0.10650
1.5	1.12394	0.07543	1.11582	0.07837	1.14896	0.09728
2.2	1.11404	0.06493	1.10691	0.06636	1.13061	0.08115
3	1.10273	0.05292	1.09674	0.05263	1.10964	0.06271
3.7	1.09283	0.04242	1.08783	0.04061	1.09129	0.04657
4	1.09189	0.04167	1.08686	0.03971	1.08982	0.04534
5.5	1.08902	0.04000	1.08361	0.03759	1.08603	0.04236
7.5	1.08518	0.03778	1.07927	0.03476	1.08097	0.03838
11	1.07848	0.03389	1.07168	0.02980	1.07211	0.03142
15	1.07093	0.02952	1.06311	0.02422	1.06213	0.02360
18.5	1.06955	0.02924	1.06045	0.02296	1.05976	0.02261
22	1.06817	0.02895	1.05778	0.02171	1.05739	0.02163
30	1.06502	0.02829	1.05168	0.01883	1.05197	0.01937
37	1.06226	0.02772	1.04635	0.01631	1.04723	0.01740
45	1.05937	0.02579	1.04430	0.01554	1.04548	0.01690
55	1.05578	0.02333	1.04194	0.01468	1.04347	0.01636
75	1.04871	0.01848	1.03732	0.01299	1.03954	0.01528
90	1.04741	0.01820	1.03731	0.01326	1.03949	0.01474
110	1.04569	0.01782	1.03729	0.01362	1.03943	0.01403
132	1.04380	0.01740	1.03728	0.01401	1.03936	0.01323
150	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
160	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
185	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
200	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
220	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
250	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
300	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262

Annex E
Example Calculations (Informative)

E.1 Worked example for a housed centrifugal fan with belt transmission operating DOL

A housed centrifugal fan is selected to deliver 5.94 m^3/s (12,000 cfm) at a fan total pressure of 1250 Pa (5 in. wg). The input power to the fan, H_i, is 15.8 kW (11.8 hp) and fan speed is 1500 rpm. The fan is driven through a V-belt transmission with a 15 hp, four-pole ODP premium efficiency motor regulated under EISA 2007.

1. Calculate the transmission efficiency, η_B

$$\eta_B = 0.96 \left(\frac{H_i}{H_i + 2.2}\right)^{0.05} = 0.96 \left(\frac{11.8}{11.8 + 2.2}\right)^{0.05} = 95.2\%$$

2. Calculate the motor output power, H_m

$$H_m = \frac{H_i}{\eta_B} = \frac{11.8}{0.952} = 12.4 \text{ hp } (9.3 \text{ kW})$$

3. Calculate the motor load ratio, L_m

$$L_m = \frac{H_m}{H_{mo}} = \frac{12.4}{15.0} = 0.827$$

4. Calculate the motor efficiency, η_m. Obtain the motor nominal efficiency, η_R, from Table A1 and the motor performance constants, *a* and *b*, from Table D1. The constant *c* is calculated from *a* and *b*.

$$c = 1 - \frac{a}{b + 1}$$

$$\eta_m = \eta_R \left(\frac{aL_m}{b + L_m} + cL_m^2\right) = 0.93 \left(\frac{1.07127 \cdot 0.827}{0.02953 + 0.827} + (-0.0405)(0.827)^2\right) = 93.6\%$$

The motor input power is then calculated as

$$W_c = \frac{0.746\, H_i}{\eta_m \eta_B} = \frac{0.746 \cdot 11.8}{0.936 \cdot 0.952} = 9.9 \text{ kW}$$

E.2 Worked example for a direct drive unhoused centrifugal fan with a VFD

A direct drive unhoused centrifugal fan is selected to deliver 3.0 m^3/s (6350 cfm) at a fan static pressure of 1000 Pa (4 in. wg). The input power to the fan, H_i, is 4.4 kW (5.9 hp) and the fan speed is 2100 rpm. The fan is directly coupled to a 5.5 kW, four-pole IE3 motor regulated under IEC 60034-30 and driven by a 5.5 kW VFD.

1. The fan is directly coupled to the motor, so $\eta_B = 1$ and $H_m = 4.4$ kW.
2. Calculate the motor load ratio, L_m

$$L_m = \frac{H_m}{H_{mo}} = \frac{4.4}{5.5} = 0.80$$

3. Calculate motor efficiency, η_m. Obtain the motor nominal efficiency, η_R, from Table A2 and the motor performance constants, *a* and *b*, from Table B2. The constant *c* is calculated from *a* and *b*.

$$c = 1 - \frac{a}{b+1}$$

$$\eta_m = \eta_R \left(\frac{aL_m}{b + L_m} + cL_m^2\right)$$

$$= 0.896 \left(\frac{1.04088\,.\,0.80}{0.01454 + 0.80} + (-0.02596)(0.80)^2\right) = 90.1\%$$

4. Calculate the control (VFD) load ratio, L_c

$$L_c = \frac{L_m H_{mo}}{\eta_m H_{co}} = \frac{0.8 * 5.5}{0.901 * 5.5} = 0.888$$

5. Calculate the motor/VFD efficiency, η_{mc}. Obtain the VFD constants *d, e,* and *f* from Table C2.

$$\eta_{mc} = \eta_m \left(\frac{dL_c}{e + L_c} + fL_c\right)$$

$$= 0.901 \left(\frac{0.97807\,.\,0.888}{0..02546 + 0.888} + (-0.00052)(0.888)\right) = 85.6\%$$

The motor input power is then calculated as

$$W_c = \frac{H_i}{\eta_{mc}\eta_B} = \frac{4.4}{0.888 \times 1.0} = 4.9 \text{ kW}$$

E.3 Worked example for a direct unhoused centrifugal fan with a VFD and specified load profile

The motor is a 20 hp, four-pole ODP, regulated under EISA 2007. The VFD has a capacity of 20 hp. The fan for a variable air volume (VAV) system is selected to operate under the following conditions:

Q **(cfm)**	**Fan Static Pressure (in. wg)**	***H*** **(hp)**	***N*** **(rpm)**	**Duty Fraction**
12500	6.0	16.4	1385	5%
12000	5.6	14.7	1336	20%
11000	5.0	12.1	1253	20%
10000	4.2	9.2	1147	20%
9000	3.6	7.2	1062	20%
8000	3.0	5.3	958	10%
6000	2.2	2.9	806	5%

The duty fraction is the portion of time that the fan operates under the indicated conditions. Each operating point is treated separately. The first duty point is illustrated here:

1. The fan is directly coupled to the motor, so η_B = 1 and H_m = 16.4 hp
2. Calculate the motor load ratio, L_m

$$L_m = \frac{H_m}{H_{mo}} = \frac{16.4}{20} = 0.82$$

3. Calculate motor efficiency, η_m. Obtain the motor nominal efficiency, η_R, from Table A1 and the motor performance constants, *a* and *b*, from Table B1. The constant *c* is calculated from *a* and *b*.

$$c = 1 - \frac{a}{b+1}$$

$$\eta_m = \eta_R \left(\frac{aL_m}{b+L_m} + cL_m^2\right) = 0.93\left(\frac{1.03021 \cdot 0.82}{0.00696 + 0.82} + (-0.02309)(0.82)^2\right) = 93.6\%$$

4. Calculate the control (VFD) load ratio, L_c

$$L_c = \frac{L_m H_{mo}}{\eta_m H_{co}} = \frac{0.82 \cdot 20}{0.936 \cdot 20} = 0.876$$

5. Calculate the motor/VFD efficiency, η_{mc}. Obtain the VFD constants *d, e*, and *f* from Table C1.

$$\eta_{mc} = \eta_m \left(\frac{dL_c}{e+L_c} + fL_c\right)$$

$$= 0.936 \left(\frac{0.98500 \times 0.876}{0.01750 + 0.876} + (-0.00050)(0.876)\right) = 90.3\%$$

The motor input power is then calculated as

$$W_c = \frac{0.746 H_i}{\eta_{mc}\eta_B} = \frac{0.746 \cdot 16.4}{0.903 \cdot 1.0} = 13.5 \text{ kW}$$

Each duty point is calculated in a similar fashion. The result is summarized in the table below. The net energy usage at each duty point and the total cost assuming 0.12 USD/kWh is also shown.

VAV System Example												
Q (cfm)	Fan Static Pressure (in. wg)	H_i (hp)	N (rpm)	Duty Fraction	L_m	η_m	L_c	η_B	η_{mc}	W_c (kW)	Energy Usage (kWh)	Cost @ 0.12 USD/kWh
12500	6	16.4	1385	5%	82.0%	93.6%	87.6%	100.0%	90.3%	13.5	5,910	709
12000	5.6	14.7	1336	20%	73.5%	93.8%	78.4%	100.0%	90.3%	12.1	21,200	2,540
11000	5.0	12.1	1253	20%	60.5%	93.9%	64.4%	100.0%	90.0%	10.0	17,500	2,100
10000	4.2	9.2	1147	20%	46.0%	93.9%	49.0%	100.0%	89.3%	7.7	13,000	1,600
9000	3.6	7.2	1062	20%	36.0%	93.7%	38.4%	100.0%	88.3%	6.1	11,000	1,300
8000	3.0	5.3	958	10%	26.5%	93.2%	28.4%	100.0%	86.5%	4.6	4,000	480
6000	2.2	2.9	806	5%	14.5%	91.4%	15.9%	100.0%	81.1%	2.7	1,200	140

Annex F
Statement of Uncertainty (Informative)

The calculations described in this document are intended to provide users with standardized estimates of fan system input power. Given the large number of possible component configurations and fan operating conditions, this is a practical alternative to testing each configuration. The models adopted here account for the physical behavior of each component with various degrees of fidelity. Considering variations in manufacturer designs, installation practices, control settings and design versus actual operation conditions, the user should expect a difference between this calculation and a tested fan system. Therefore, caution is advised when comparing the calculated result to tested configurations with like components.

The motor efficiency model is based on an alternate efficiency determination method (AEDM) [9]. The AEDM uses a combination of finite element analysis and lumped parameter equivalent circuit and thermal models to simulate motor performance. AEDMs are common in the motor industry to offset testing burden in support of the Energy Policy and Conservation Act. The AEDM was used to simulate DOL and constant V/Hz variable frequency motor operation. In both cases the input power was a pure sine wave and did not account for line voltage quality, VFD carrier frequency and other factors that are prohibitively difficult to model and simulate. Despite these shortcomings, the motor efficiency is believed to have an estimated uncertainty proportional to the difference between the nominal efficiency and minimum efficiency. This range is from 3.5 pts for a 1 hp motor and 0.8 pts for a 200 hp motor. This uncertainty is expected to be somewhat higher at lower motor load ratios and for VFD operation.

The belt loss efficiency model published in AMCA Publication 203 [10] has been adopted by this standard. Belt performance ultimately depends on many factors including belt speed, sheave diameter and belt cross section geometry, as well as maintenance issues including alignment and tension. Flexural losses tend to be independent of power transmitted for a given belt drive geometry, so belt transmission efficiencies increase with power transmitted. The curves presented in AMCA Publication 203 suggest that belt losses can vary up to 5 percent at 1 hp and 2 percent at 100 hp for a properly installed belt drive transmission. There is currently no test standard or regulatory requirement for belt drive transmissions.

The VFD efficiency model is based on the DOE's Motor Tip Sheet #11 [11]. VFDs are solid state electronic devices that offer the user a wide variety of configurations and settings. For example, a VFD can be configured to provide 30 Hz output with many combinations of carrier frequency and/or V/Hz relationship. Different combinations of these parameters can significantly affect performance [12]. The constant V/Hz relationship, adopted in the motor model, is believed to be conservative. Given the absence of VFD regulatory requirements, manufacturer variations and control settings, expect the combined VFD/motor efficiency uncertainty to be greater than that of the motor operating DOL.

Annex G
References

G.1 Normative References

1. ANSI/AMCA Standard 210 & ANSI/ASHRAE 51. Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating. Arlington Heights: AMCA, 2016.
2. ANSI/AMCA Standard 230. Laboratory Methods of Testing Air Circulating Fans for Rating and Certification. Arlington Heights: AMCA, 2015.
3. ANSI/AMCA Standard 260. Laboratory Methods of Testing Induced Flow Fans for Rating. Arlington Heights: AMCA, 2013.
4. ISO 5801. Industrial Fans—Performance testing using standardized airways. Geneva: ISO, 2007
5. AMCA Publication 211. Certified Ratings Program—Product Rating Manual for Fan Air Performance. Arlington Heights: AMCA, 2015.
6. EPCA. Code of Federal Regulations. Title 10. Chapter II, Subchapter D, Part 431, Subpart B. 110th Cong., 1st sess., 2007.
7. IEC 60034-30-1:2014. Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code). Geneva: IEC, 2014
8. GB 18613. Minimum Allowable Values of Energy Efficiency and Energy Efficiency Grades for Small and Medium Three-Phase Asynchronous Motors. Beijing: Standardization Administration of China, 2011.
9. Nidec Corporation. “AEDM Simulations to Support AMCA 207 Development.” Helmuth Glatt. 2013.
10. AMCA Publication 203. Field Performance Measurement of Fan Systems. “Figure L.1: Estimated Belt Drive Loss.” Arlington Heights: AMCA, 2010.
11. “Energy Tips: Motors.” “Motor Systems Tip Sheet #11: Adjustable Speed Drive Part-Load Efficiency.” Washington, D.C.: DOE, 2012. Accessed March 23, 2017. http://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/motor_tip_sheet11.pdf
12. Krukowski, A. and C. P. Wray. “Standardizing Data for VFD Efficiency.” ASHRAE Journal. Atlanta: ASHRAE, 2013.

G.2 Informative References

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- GB 18316. Specifications for inspection, acceptance and quality assessment of digital surveying and mapping achievements. Beijing: Standardization Administration of China, 2008.
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- Code of Federal Regulations. Title 10, Chapter II, Subchapter D, Part 431, Subpart B, Section 431.2. College Park, MD: Federal Registrar, 2016.

TECHNICAL ERRATA SHEET FOR
ANSI/AMCA STANDARD 207-17
Fan System Efficiency and Fan System Input Power Calculation

December 5, 2017

The corrections listed in this errata sheet apply to all copies of ANSI/AMCA Standard 207-17. The corrections are not part of the approved published AMCA document.

1. In section 4.1.3.1, paragraph 6
2. Table A1, “EPCA Nominal Motor Efficiency (60 Hz motors)

Editorial Errata

1. In section 4.1.3.1, paragraph 6, the term η_B should be η_R. The paragraph will then read (change is in red text),

> "The combined motor and VFD efficiency is calculated in the following steps. First, the motor efficiency is calculated as
>
> $$\eta_m = \eta_R \left(\frac{aL_m}{b + L_m} + cL_m^2 \right)$$
>
> Where η_R is the nominal motor efficiency obtained from Table A1 (EPCA), Table A2 (IEC 63034-30-1) or Table A3 (GB 18613), depending on the applicable motor configuration. L_m is the motor load ratio calculated by … ."

2. Table A1, "EPCA Nominal Motor Efficiency (60 Hz motors)" is corrected on the following page. Values underlined and in red are the corrected values. All values in the Table were extracted from the e-CFR, 10 CFR 431.25, Table 5, "Nominal Full-Load Efficiencies of NEMA Design A, NEMA Design B and IEC Design N Motors (Excluding Fire Pump Electric Motors) at 60 Hz."

Annex A
Motor Efficiencies (Normative)

Table A1. EPCA Nominal Motor Efficiency (60 Hz motors)

Motor Power/Standard Kilowatt Equivalent	ODP				TEFC			
	2 POLE	4 POLE	6 POLE	8 POLE	2 POLE	4 POLE	6 POLE	8 POLE
1/.75	77.0	85.5	82.5	75.5	77.0	85.5	82.5	75.5
1.5/1.1	84.0	86.5	86.5	77.0	84.0	86.5	87.5	78.5
2/1.5	85.5	86.5	87.5	86.5	85.5	86.5	88.5	84.0
3/2.2	85.5	89.5	88.5	87.5	86.5	89.5	89.5	85.5
5/3.7	86.5	89.5	89.5	88.5	88.5	89.5	89.5	86.5
7.5/5.5	88.5	91.0	90.2	89.5	89.5	91.7	91.0	86.5
10/7.5	89.5	91.7	91.7	90.2	90.2	91.7	91.0	89.5
15/11	90.2	93.0	91.7	90.2	91.0	92.4	91.7	89.5
20/15	91.0	93.0	92.4	91.0	91.0	93.0	91.7	90.2
25/18.5	91.7	93.6	93.0	91.0	91.7	93.6	93.0	90.2
30/22	91.7	94.1	93.6	91.7	91.7	93.6	93.0	91.7
40/30	92.4	94.1	94.1	91.7	92.4	94.1	94.1	91.7
50/37	93.0	94.5	94.1	92.4	93.0	94.5	94.1	92.4
60/45	93.6	95.0	94.5	93.0	93.6	95.0	94.5	92.4
75/55	93.6	95.0	94.5	94.1	93.6	95.4	94.5	93.6
100/75	93.6	95.4	95.0	94.1	94.1	95.4	95.0	93.6
125/90	94.1	95.4	95.0	94.1	95.0	95.4	95.0	94.1
150/110	94.1	95.8	95.4	94.1	95.0	95.8	95.8	94.1
200/150	95.0	95.8	95.4	94.1	95.4	96.2	95.8	94.5
250/186	95.0	95.8	95.8	95.0	95.8	96.2	95.8	95.0
300/224	95.4	95.8	95.8		95.8	96.2	95.8	
350/261	95.4	95.8	95.8		95.8	96.2	95.8	
400/298	95.8	95.8			95.8	96.2		
450/336	96.2	96.2			95.8	96.2		
500/373	96.2	96.2			95.8	96.2		

Reference: NEMA MG-1, Table 12-12

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