STANDARD

ANSI/AMCA Standard 205-19

Energy Efficiency Classification for Fans

An American National Standard
Approved by ANSI on May 3, 2019

Air Movement and Control Association International

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Energy Efficiency Classifications for Fans

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AMCA Standard

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Contents

Energy Efficiency Classification for Fans

1. Purpose

This standard defines the energy efficiency classification for fans.

2. Scope

The scope includes fans having an impeller diameter of 125 mm (5 in.) or greater, operating with an impeller shaft power of 750 W (1 hp) and above and having a fan total efficiency calculated according to one of the following fan test standards: ANSI/AMCA Standard 210, AMCA Standard 260 or ISO 5801. All other fans are excluded. This standard only applies to the fan, not the fan drive or the fan system.

3. Normative References

The following referenced documents shall be utilized for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document, including any amendments, applies.

ANSI/AMCA Standard 99, Standards Handbook
ANSI/AMCA Standard 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating
AMCA Standard 260, Laboratory Methods of Testing Induced Flow Fans for Rating
IEEE 112-2004, Standard Test Procedure for Polyphase Induction Motors and Generators
IEEE 114-2001, Standard Test Procedure for Single-Phase Induction Motors
ISO 5801, Industrial Fans - Performance Testing Using Standardized Airways
ISO 12759:2010, Fans - Efficiency Classification for Fans
ISO 13348:2007, Industrial Fans - Tolerances, Methods of Conversion and Technical Data Presentation
ISO 13349:2008, Industrial Fans - Vocabulary and Definitions of Categories

4. Definitions/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 3.

4.1 Definitions

4.1.1 Fan
A rotary machine that imparts energy to an air stream and by means of one or more impellers fitted with blades to maintain quasi continuous flow with a fan pressure rise that does not normally exceed 30 kPa (120 in. wg).

Note: The pressure limit corresponds approximately to a fan specific work of 25 kJ/kg.

4.1.2 Impeller diameter
For the purpose of fan efficiency grade (FEG) classification, impeller diameter is the largest diameter of the circle inscribed by the rotating impeller blade tips.

4.1.3 Fan drives (transmission, motor/control system)
Any device used to power a fan, including a motor, mechanical transmission (e.g., belt drive, coupling, etc.) and motor/control system (e.g., variable frequency controller, electronic commutator, etc.).

4.1.4 Fan without a drive
A fan with its impeller attached to a fan shaft supported by bearings (see Figure 1).

4.1.5 Fan with a drive
A fan with a drive (see Figure 2).

4.1.6 Air
Term used as abbreviation for “air or other gas.”

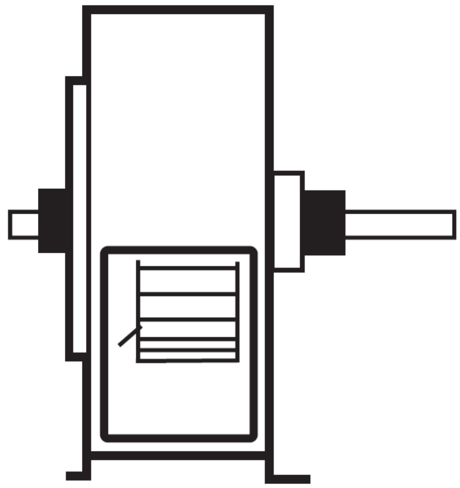
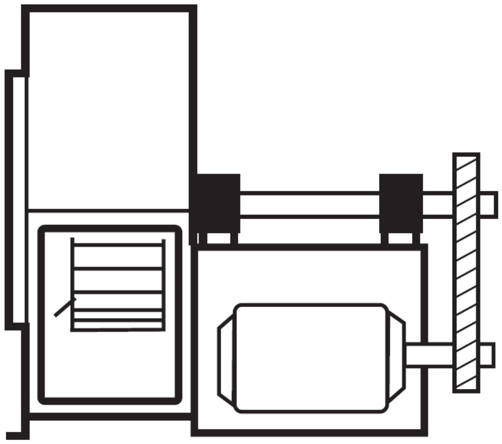


Figure 1 — Fan Without a Drive



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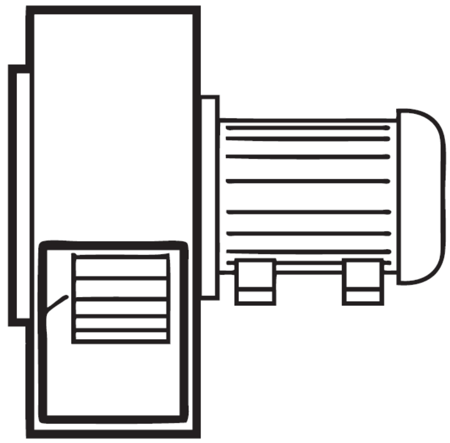

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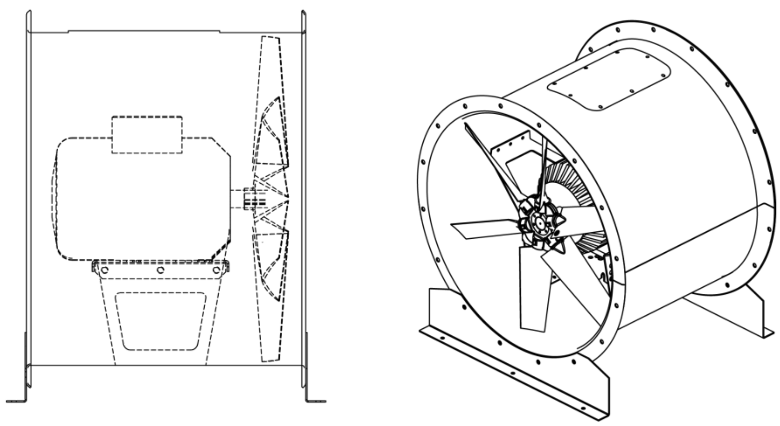

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Figure 2 — Fans with Drives

4.1.7 Fan pressures

4.1.7.1 Fan total pressure (P_t)
The difference between the total pressure at the fan outlet and the total pressure at the fan inlet.

4.1.7.2 Fan velocity pressure (P_v)
The velocity pressure corresponding to the average velocity at the fan outlet.

4.1.8 Fan air power (H_o)
Fan power output, which is the product of the inlet flow rate, fan total pressure and compressibility coefficient.

Note**:** For incompressible flow, the compressibility coefficient is equal to 1.

4.1.9 Fan shaft power (H_{sh})
Mechanical power supplied to the fan shaft.

Note: The power loss in the fan shaft bearings is considered a fan internal loss.

4.1.10 Fan impeller power (H_i)
Motor output power supplied to the impeller of a direct driven fan where the impeller is attached to the motor shaft.

4.1.11 Fan peak efficiency (η_{pk})
Maximum fan total efficiency with the fan speed and air density being fixed.

4.1.12 Fan efficiency grade (FEG)
The efficiency grade of a fan without consideration of the drives.

4.2 Symbols
See Table 1.

Table 1 — Symbols and Subscripts

Symbol	Description	SI Unit	I-P Unit
D	Impeller diameter	mm	in.
D_0	Impeller diameter for a base fan	mm	in.
E_{year}	Annual energy consumption	kWh	kWh
H_i	Fan impeller power	W	hp
H_o	Fan air power	W	hp
H_{sh}	Fan shaft power	W	hp
P_t	Fan total pressure	Pa	in. wg
P_v	Fan velocity pressure	Pa	in. wg
$\eta 85_D^{upp}$	Upper limit efficiency of FEG85	%	%
$\eta 85_{D0}^{upp}$	Upper limit efficiency of FEG85 of the base fan	%	%
η_i	Efficiency of direct driven fans without drives	dimensionless or %	
η_{pk}	Peak fan efficiency	dimensionless or %	
η_{sh}	Efficiency of fans without drives	dimensionless or %	
η_t	Total fan energy efficiency	dimensionless or %	

Table 2 — Fan Test Application Categories

Category	Duct Configuration
A	No ducts attached to the fan inlet or outlet
B	No duct attached to the fan inlet; duct attached to the fan outlet
C	Duct attached to the fan inlet; no duct attached to the fan outlet
D	Ducts attached to the fan inlet and outlet

5. General

5.1 Use of test installation categories

The fan test application category (test configuration) may have an impact on the determination of the fan peak efficiency. The category distinguishes arrangement of ducts to the fan inlet and outlet (see Table 2).

5.2 Fan energy efficiency calculations

For the purpose of this standard, the fan energy efficiency is calculated from the formulas in sections 5.2.1 and 5.2.2.

5.2.1 Efficiency of a fan without drives

$$\eta_{sh} = \frac{H_o}{H_{sh}}$$

5.2.2 Efficiency of a direct driven fan without consideration of the drives

$$\eta_i = \frac{H_o}{H_i}$$

6. Efficiency Classifications for Fans

6.1 General

The fans within the scope of this standard shall be classified for their fan efficiency using the FEG. The FEG is an indicator of the fan's aerodynamic ability to convert shaft power, or impeller power in the case of a direct driven fan, to air power. The FEG will be most useful in evaluating the aerodynamic quality of the fan and will be the only metric useful when the fan is evaluated independently of the motor/control. This classification is a distinct metric that serves a specific purpose and allows comparison of any number of fans using this same metric. This classification shall not be used simultaneously or interchangeably with any other fan energy classification.

While the fan efficiency is a function of the operating point on the fan performance curve, the FEG is based on the peak, or optimum, efficiency. The FEG is the characteristic that defines the fan's energy usage quality and indicates the potential for minimizing the fan's energy usage.

Different test application categories (test configurations) may yield different peak efficiencies. If a fan can be used in more than one of the categories, the highest peak efficiency of all the categories may be used for the classification. The test application category used for determination of the peak efficiency shall be indicated with the classification grade.

6.2 FEG classification of fan efficiency

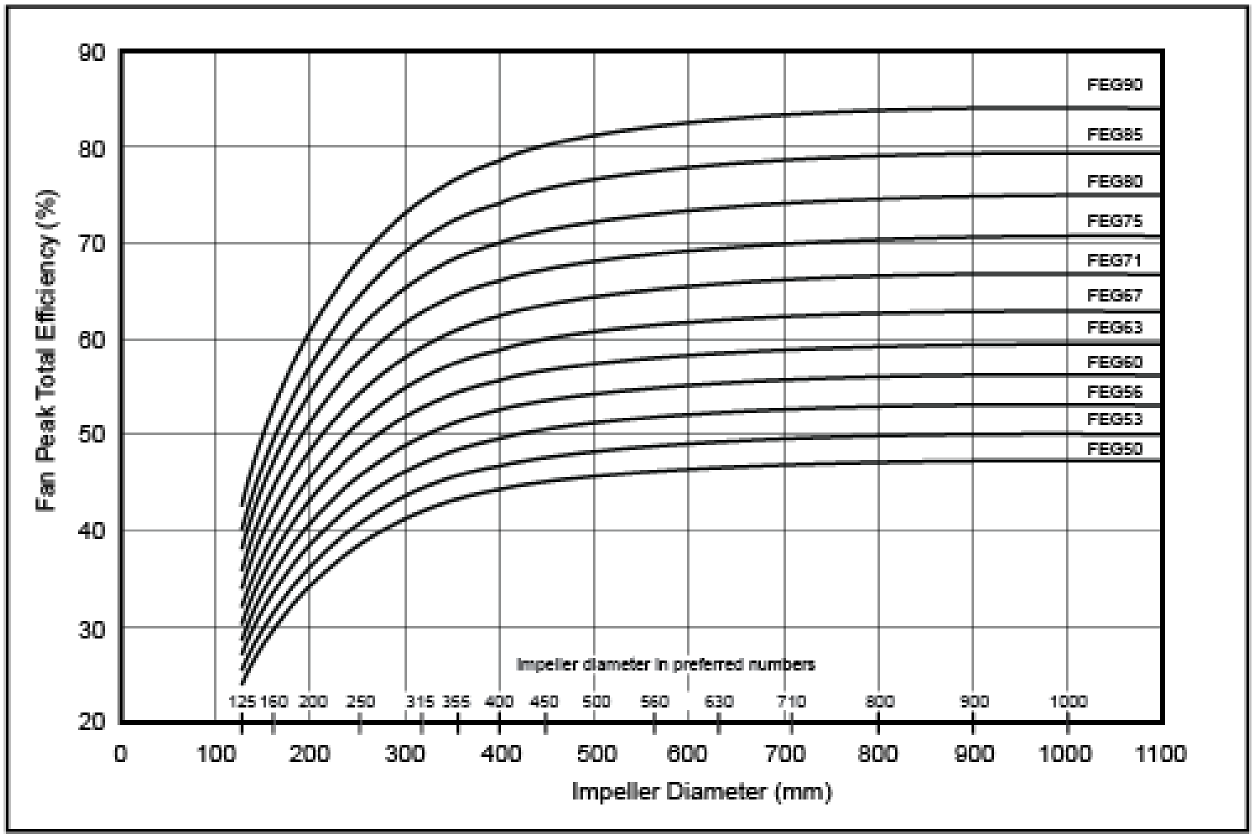
This classification is based on total peak, or optimum, fan efficiency for a given fan speed, impeller diameter and test application category (test configuration). For the purpose of energy classification, the peak efficiency shall be determined at a speed that is lower than the fan's maximum design speed. In the case of variable geometry fans, it is advisable that the FEG be determined at the physically achievable blade angle that produces maximum efficiency. The relationship between the FEG and the impeller diameters is shown in figures 3a and 3b.

An FEG label for a given fan impeller diameter is assigned when the fan peak efficiency is equal to or lower than the calculated FEG's upper limit and higher than the calculated FEG's lower limit. The FEG for a given impeller diameter and peak efficiency shall be calculated using the formulas indicated in Annex A.

For example, a fan with an impeller diameter of 500 mm (19.7 in.) at a speed of 1,800 rpm in test application category C has a peak efficiency of 79%. The fan belongs in FEG85 because the fan impeller diameter's fan efficiency is below the FEG's upper limit of 81.5% and higher than the FEG's lower limit of 76.9%.

When the fan has been tested integrally with the motor, the shaft power shall be determined by measuring the input electrical power and motor efficiency, which must be determined via calibration per IEEE 112-2004 or IEEE 114-2001.

Other estimation methods (e.g., using ratios of amperage to full load amperage, etc.) shall not be acceptable.

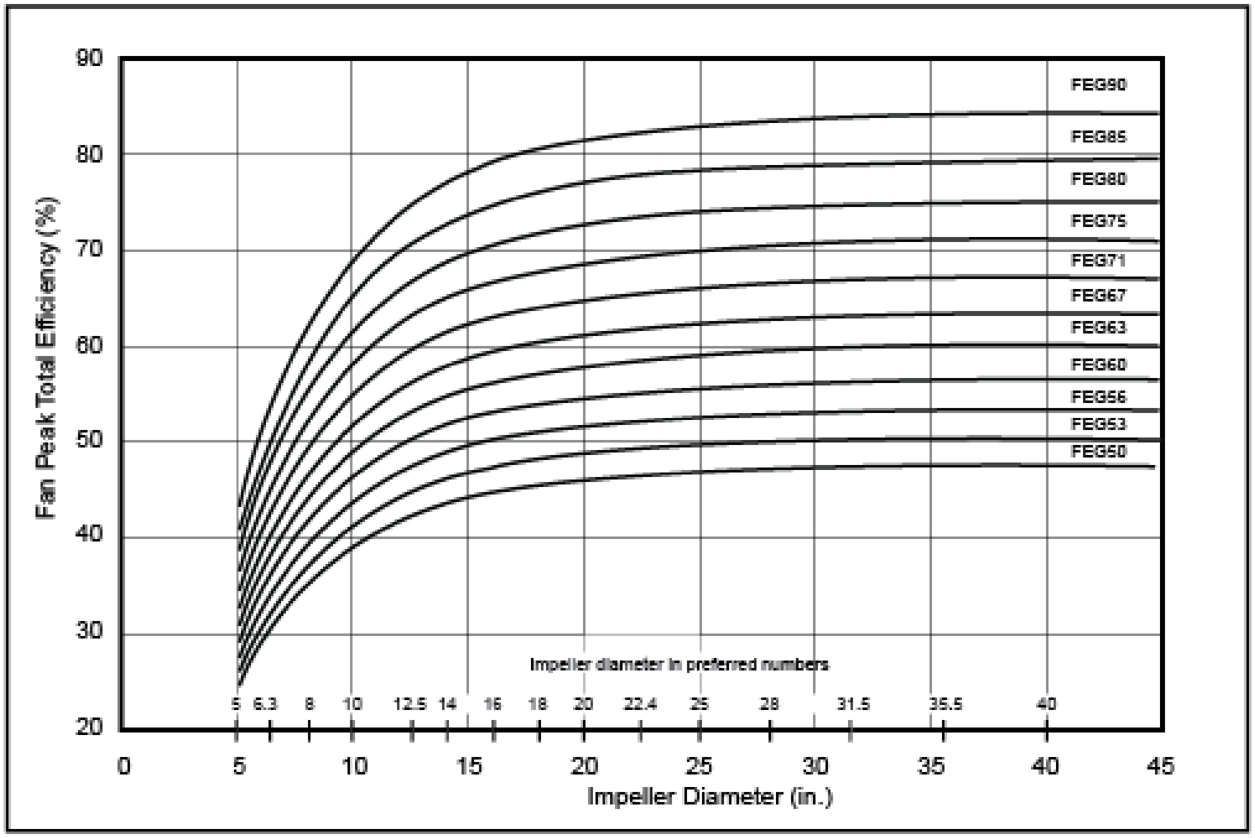


Notes:

1. The fan peak efficiency shall be calculated from the fan total pressure.
2. If this method is used for a direct driven fan, the fan efficiency is the impeller efficiency.
3. The FEG label for a given impeller diameter is assigned when the fan peak efficiency is equal to or lower than the FEG's upper limit and higher than the FEG's upper limit of the impeller diameter's next lower FEG.
4. For any impeller diameters larger than 1,016 mm, the values of the FEG's upper limits are the same as those for an impeller diameter equal to 1,016 mm.
5. No labels are considered for fans with peak total efficiency below FEG50.
6. Efficiency values are calculated for impeller diameters in the preferred R40 Series.

7. Not all impeller diameters in preferred numbers are shown.

Figure 3a — FEG for Fans Without Drives (SI)



Notes:
1. The fan peak efficiency shall be calculated from the fan total pressure.
2. If this method is used for a direct driven fan, the fan efficiency is the impeller efficiency.
3. The FEG label for a given impeller diameter is assigned when the fan peak efficiency is equal to or lower than the FEG's upper limit and higher than the FEG's upper limit of the impeller diameter's next lower FEG.
4. For any impeller diameters larger than 40 in., the values of the FEG's upper limits are the same as those for an impeller diameter equal to 40 in.
5. No labels are considered for fans with peak total efficiency below FEG50.
6. Efficiency values are calculated for impeller diameters in the preferred R40 Series.
7. Not all impeller diameters in preferred numbers are shown.

Figure 3b — FEG for Fans Without Drives (I-P)

7. (Informative) Use of FEG in Codes and Specifications

Any code or specification that requires an FEG also shall require that the fan efficiency, at all intended operating points, be within 15 or fewer percentage points of the fan peak efficiency. The restriction imposed by this limitation is explained in Annex B.

Example:
A certain regulation specifies FEG67 as well as an operational fan efficiency within 12 percentage points of the fan peak efficiency. If the fan considered for use has a peak efficiency of 65%, the operational fan efficiency under this regulation shall not be below 53%.

Annex A
Energy Efficiency Grades for a Fan Without a Drive (Normative)

The formula for calculating the upper limit efficiencies of FEG85 using the impeller diameter as the independent variable is:

$$\eta 85_D{}^{upp} = k_0 + \left(81 + \frac{D}{k_1} - \left(\frac{D}{k_2}\right)^2\right)^{0.5} - 112exp\left(\frac{-D}{k_3}\right)$$

Where:

$\eta 85_D{}^{upp}$ is the efficiency value at the upper limit of FEG85 for a given impeller diameter

D is the impeller diameter in mm (in.)

D_0 is the base impeller diameter of 1,016 mm (40 in.)

k_0, k_1, k_2, k_3 are constants

The impeller diameter, *D*, is in millimeters in the SI system of units and inches in the I-P system of units. The constants have to be used from Table A.1 accordingly.

The constants as they are defined shall be used rather than their rounded values.

For a given impeller diameter, D, the FEGD upper limits are calculated from the FEG85D upper limit (use previous formula) as numbers in a geometrical series with a quotient of:

$$q = 10^{\left(-\frac{1}{40}\right)} = 10^{-0.025} = 0.94406088\ (rounded)$$

For example, the FEG85 upper limit for an impeller diameter of 1,016 mm (40 in.) is 84.1395; the upper limit of the next lower FEG, e.g., FEG80, is calculated as 84.1395 × *q* = 79.4328. The next lower FEG is FEG75; its upper limit is calculated as 79.4328 × *q* = 74.9894, etc.

Shown in Table A.2 are the upper limits for all FEG for an impeller diameter of 1,016 mm (40 in.). The multipliers are impeller diameter independent and shall be used for calculating the upper limits of all FEG from FEG85.

Table A.1 — Constants for Defining the Upper Efficiency Limit of FEG85

Constant	SI	I-P
D_0	1,016 mm (exactly)	40 in. (exactly)
k_0	$\mathbf{10^{\left(1+\left(\frac{37}{40}\right)\right)} - 15 + 112exp\left(-\frac{D_0}{k_3}\right)}$	$\mathbf{10^{\left(1+\left(\frac{37}{40}\right)\right)} - 15 + 112exp\left(-\frac{D_0}{k_3}\right)}$
k_1	$\mathbf{\frac{793.75}{15^2} = 3.52\overline{77}}$	$\mathbf{\frac{31.25}{15^2} = 0.13\overline{88}}$
k_2	$\mathbf{\frac{1270}{15} = 84.\overline{66}}$	$\mathbf{\frac{50}{15} = 3.\overline{33}}$

k_3	113.92 (exactly)	$\frac{\mathbf{113.92}}{\mathbf{25.4}} = \mathbf{4.48503937}$

Table A.2 — FEG Upper Limits for an Impeller Diameter of 1,016 mm (40 in.) and Multipliers for Calculating Upper Limits of all FEG from FEG85

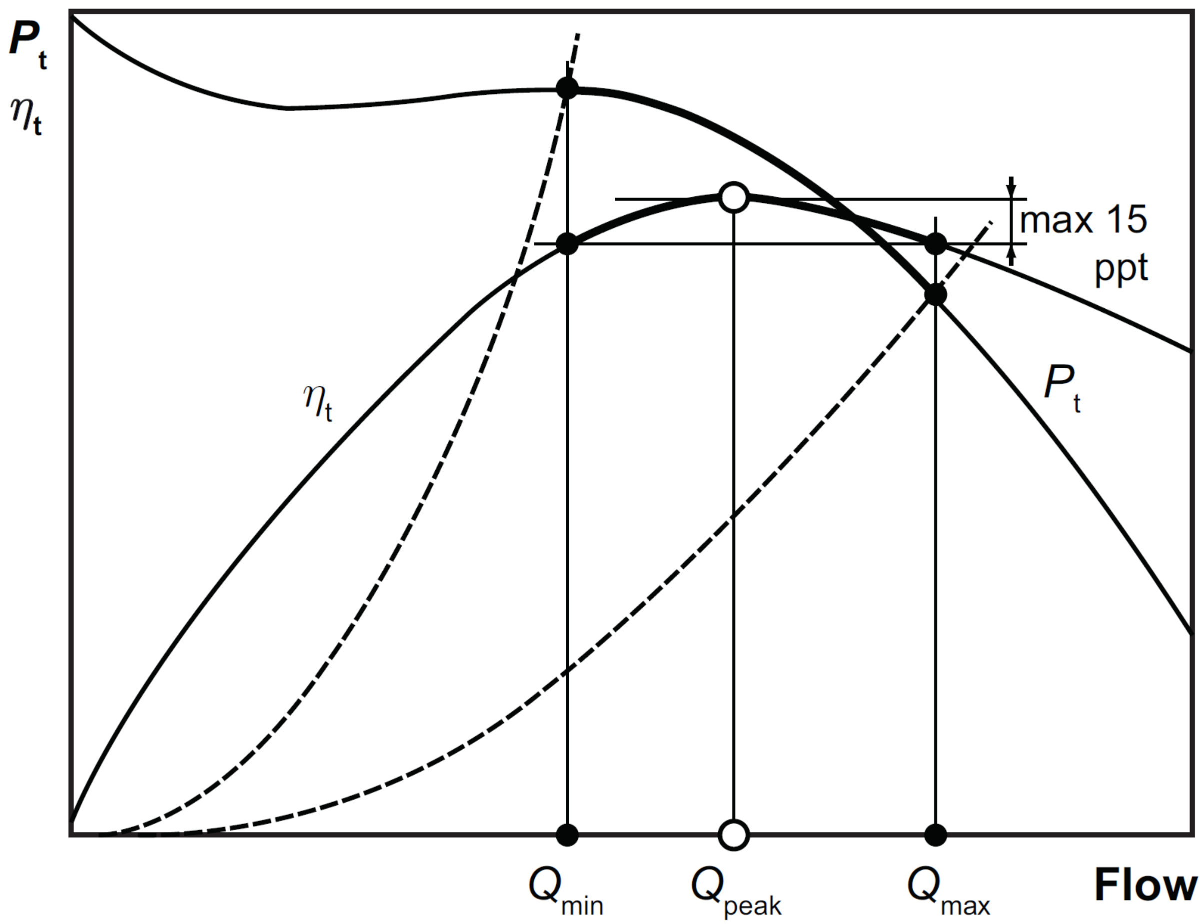
FEG	FEG Upper Limit (Exact Values from Renard Formula)	FEG Upper Limit (Rounded)	Multiplier from FEG85 (Exact Values)	Multiplier from FEG85 (Rounded)
FEG85	$10^{\left(1+\left(\frac{37}{40}\right)\right)}$	84.1395	1	1
FEG80	$10^{\left(1+\left(\frac{36}{40}\right)\right)}$	79.4328	$10^{\left(\left(\frac{39}{40}\right)-1\right)}$	0.94406088
FEG75	$10^{\left(1+\left(\frac{35}{40}\right)\right)}$	74.9894	$10^{\left(\left(\frac{38}{40}\right)-1\right)}$	0.89125094
FEG71	$10^{\left(1+\left(\frac{34}{40}\right)\right)}$	70.7946	$10^{\left(\left(\frac{37}{40}\right)-1\right)}$	0.84139514
FEG67	$10^{\left(1+\left(\frac{33}{40}\right)\right)}$	66.8344	$10^{\left(\left(\frac{36}{40}\right)-1\right)}$	0.79432823
FEG63	$10^{\left(1+\left(\frac{32}{40}\right)\right)}$	63.0958	$10^{\left(\left(\frac{35}{40}\right)-1\right)}$	0.74989421
FEG60	$10^{\left(1+\left(\frac{31}{40}\right)\right)}$	59.5663	$10^{\left(\left(\frac{34}{40}\right)-1\right)}$	0.70794578
FEG57	$10^{\left(1+\left(\frac{30}{40}\right)\right)}$	56.2342	$10^{\left(\left(\frac{33}{40}\right)-1\right)}$	0.66834392
FEG53	$10^{\left(1+\left(\frac{29}{40}\right)\right)}$	53.0885	$10^{\left(\left(\frac{32}{40}\right)-1\right)}$	0.63095734
FEG50	$10^{\left(1+\left(\frac{28}{40}\right)\right)}$	50.1188	$10^{\left(\left(\frac{31}{40}\right)-1\right)}$	0.59566214

Table A.3 — FEG50 Lower Limit and Multiplier for an Impeller Diameter of 1,016 mm (40 in.) and Multipliers for Calculating the Lower Limit of the FEG from the Upper Limit of FEG85

FEG	FEG Lower Limit (Exact Values From Renard Formula)	FEG Lower Limit (Rounded)	Multiplier from FEG85 (Exact Values)	Multiplier from FEG85 (Rounded)
FEG50	$10^{\left(1+\left(\frac{27}{40}\right)\right)}$	47.3151	$10^{\left(\left(\frac{30}{40}\right)-1\right)}$	0.56234133

Annex B
Fan Efficiency Range for System Fan Selection (Informative)

Energy efficient fan operation requires that the system fan is selected close to peak fan efficiency. The fan operating efficiency at all intended operating points shall be less than 15 percentage points below fan peak efficiency (see portions of the fan curves with heavy lines in Figure B.1).



P_t is the fan total pressure
η_t is the fan total energy efficiency
Q is the flow
Q_{min}, Q_{max} represent the flow range for the allowable fan efficiency range

Figure B.1 — Fan Efficiency and Flow Range Allowance for an Application with an Outlet Duct

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