INTERNATIONAL STANDARD

ISO 12759-4

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Fans — Efficiency classification for fans —

Part 4:
Driven fans at maximum operating speed

Ventilateurs — Classification du rendement des ventilateurs —

Partie 4: Ventilateurs entraînés à vitesse maximale de fonctionnement

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 117, *Fans*.

This first edition of ISO 12759-4, together with ISO 12759-1, ISO 12759-2, ISO 12759-3, ISO 12759-5[1) and ISO 12759-6[2), cancels and replaces ISO 12759:2010, which has been technically revised. It also incorporates the Amendment ISO 12759:2010/Amd.1:2013.

A list of all parts in the ISO 12759 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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1)   Under preparation. Stage at the time of publication: ISO/DIS 12759-5:2019.

2)   Under preparation. Stage at the time of publication: ISO/CD 12759-6:2019.

Introduction

The last decade has seen an escalation in the price and an increasing recognition of the finite life of many of the fossil fuels currently used. There is also a belief by many that climatic change is due to increasing levels of carbon dioxide in the atmosphere. This has led to many nations reviewing methods of energy generation and usage.

To maintain economic growth there is therefore a need to promote energy efficiency. This requires better selection of equipment by users and thus better design of this equipment by manufacturers.

Fans of all types are used for ventilation, air conditioning, process engineering – drying, pneumatic conveying – combustion air supply and agriculture. Indeed, the energy use of fans has been calculated to account for nearly 20 % of the global electricity usage.

The fan industry is global in nature, with a considerable degree of exporting and licensing. To ensure that the definitive fan performance characteristics are common throughout the world, a series of standards has been developed. It is the belief of the industry that there is now a need for minimum efficiency standards to be recognised. To encourage their implementation, a classification system is proposed which incorporates a series of efficiency bands. With improvements in technology and manufacturing processes, the minimum efficiency levels could be reviewed and increased over time.

This document can be used by legislators or regulatory bodies for defining future energy-saving targets.

Fans — Efficiency classification for fans —

Part 4:
Driven fans at maximum operating speed

1   Scope

This document establishes a system for the classification of fan efficiency for all fan types driven by motors of nominal rating 0,125 kW and above. It applies to driven fans only, but not to the system (finished original equipment manufacturer's product, for example box fans and roof fans or ventilation system) in which they might be installed. This document describes a number of different procedures to classify the efficiency of a fan or to apply a minimum efficiency limit (MEL). Those procedures are described in:

—   ISO 12759-3;

—   this document (ISO 12759-4);

—   ISO 12759-5;

—   ISO 12759-6.

There is no method described to compare these classifications and MEL's.

2   Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 5801:2017, *Fans — Performance testing using standardized airways*

ISO 13348:2007, *Industrial fans — Tolerances, methods of conversion and technical data presentation*

3   Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

—   ISO Online browsing platform: available at https://www.iso.org/obp

—   IEC Electropedia: available at http://www.electropedia.org/

3.1
fan
rotary-bladed machine that receives mechanical energy and utilizes it by means of one or more impellers fitted with blades to maintain a continuous flow of air or other gas passing through it and whose work per unit mass does not normally exceed 25 kJ/kg

Note 1 to entry: Fans are defined according to their installation category, function, fluid path and operating conditions (see ISO 13349).

[SOURCE: ISO 13349:2010, 3.1.1, — Notes to entry 1 and 3 were deleted.]

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

3.2
fan size
nominal diameter of the impeller

3.3
drive
mechanism used to power the fan which includes the motor, belt, couplings, chains, transmission and VFDs

EXAMPLE   Transmission drive and motor drive.

3.4
driven fan
impeller fitted to or connected to a motor, with or without a drive mechanism, housing or means of variable speed drive

Note 1 to entry: See Figure 1.

3.5
air
working fluid for tests with standardized airways shall be atmospheric air

[SOURCE: ISO 5801:2017, 3.1]

3.6
installation category A
installation with free inlet and free outlet with a partition

[SOURCE: ISO 13349:2010, 3.4.1, modified — References to ISO 5801 and ISO 5802 were deleted.]

3.7
installation category B
installation with free inlet and ducted outlet

[SOURCE: ISO 13349:2010, 3.4.2, modified — References to ISO 5801 and ISO 5802 were deleted.]

3.8
installation category C
installation with ducted inlet and free outlet

[SOURCE: ISO 13349:2010, 3.4.3, modified — References to ISO 5801 and ISO 5802 were deleted.]

3.9
installation category D
installation with ducted inlet and ducted outlet

[SOURCE: ISO 13349:2010, 3.4.4, modified — References to ISO 5801 and ISO 5802 were deleted.]

3.10
density at fan inlet
ρ_1
fluid density calculated from the absolute pressure and the static temperature at the fan inlet

3.11
fan pressure
p_f
difference between the stagnation pressure at the fan outlet and the stagnation pressure at the fan inlet

3.12
mass flow rate

q_m

mean value, over time, of the mass of air which passes through the specified airway cross-section per unit of time

3.13
inlet volume flow rate

q_{v1}

mass flow rate at the inlet divided by the corresponding mean value, over time, of the average density at the inlet

3.14
fan work per unit mass

W_m

increase in mechanical energy per unit mass of fluid passing through the fan

3.15
compressibility coefficient

k_p

ratio of the mechanical work done by the fan on the air to the work that would be done on an incompressible fluid with the same mass flow, inlet density and pressure ratio

3.16
fan air power

P_u

conventional output power which is the product of the mass flow rate and the fan work per unit mass, or the product of the inlet volume flow rate, the compressibility coefficient and the fan pressure

3.17
fan static air power

P_{us}

conventional output power which is the product of the mass flow rate and the fan work per unit mass, or the product of the inlet volume flow rate, the compressibility coefficient and the fan pressure

3.18
impeller power

P_r

mechanical power supplied to the fan impeller

[SOURCE: ISO 5801:2017, 3.45]

3.19
fan shaft power

P_a

mechanical power supplied to the fan shaft

[SOURCE: ISO 5801:2017, 3.46, modified — Note 1 to entry was deleted.]

3.20
motor output power

P_o

shaft power output of the motor or other prime mover

[SOURCE: ISO 5801:2017, 3.47]

3.21
motor input power
P_e
electrical input power supplied at the terminals of an electric motor drive without a variable speed drive

[SOURCE: ISO 5801:2017, 3.48]

3.22
drive/control electrical input power
P_{ed}
power supplied by electrical mains or equivalent energy supply to a motor system

3.23
fan impeller efficiency
η_r
fan air power divided by the impeller power

[SOURCE: ISO 5801:2017, 3.50, modified — References to quantities and formula deleted.]

3.24
fan shaft efficiency
η_a
fan air power divided by the fan shaft power

[SOURCE: ISO 5801:2017, 3.51, modified — References to quantities and formula deleted.]

3.25
overall efficiency for a fan without a variable speed drive
η_e
fan air power divided by the motor input power for the fan and motor without a variable speed drive

Note 1 to entry: The efficiency should be referred to the installation category, see Figure 2 and ISO 13349.

Note 2 to entry: For the purposes of this document efficiency should be expressed as a proportion of unity. To obtain a percentage value multiply the efficiency result by 100.

Note 3 to entry: The motor input power as defined in 3.21.

3.26
overall efficiency for a fan with a variable speed drive
η_{ed}
fan air power divided by the motor input power for the fan and motor combination with a variable speed drive

Note 1 to entry: The efficiency should be referred to the installation category, see Figure 2 and ISO 13349.

Note 2 to entry: For the purposes of this document efficiency should be expressed as a proportion of unity. To obtain a percentage value multiply the efficiency result by 100.

Note 3 to entry: The motor input power as defined in 3.22.

3.27
overall static efficiency for a fan without a variable speed drive
η_{es}
fan static air power divided by the motor input power for the fan and motor without a variable speed drive

3.28
overall static efficiency for a fan with a variable speed drive
η_{esd}
fan static air power divided by the motor input power for the fan and motor combination with a variable speed drive

3.29
optimum efficiency

η_{opt}

maximum efficiency achieved on the fan air characteristic with all operational parameters, except the air system resistance, being fixed

3.30
fan motor efficiency grade
FMEG

efficiency grade for a driven fan

Note 1 to entry: The definitions given in 3.25 to 3.28 shall apply.

4 Symbols

Symbol	Term	Unit
k_p	compressibility coefficient	
N_G	grade number	
P_a	fan shaft power	W
P_e	motor input power	W
P_{ed}	drive/control electrical input power	W
P_o	motor output power	W
P_r	impeller power	W
P_u	fan air power	W
P_{us}	fan static air power	W
p_a	atmospheric pressure	Pa
p_d	dynamic pressure at a point	Pa
p_f	fan pressure	Pa
p_{sf}	fan static pressure	Pa
p_{sg}	absolute stagnation pressure at a point	Pa
q_m	mass flow rate	kg/s
q_{v1}	inlet volume flow rate	m³/s
W_m	fan work per unit mass	J/kg
η_a	fan shaft efficiency	Expressed as a decimal
η_e	overall efficiency	Expressed as a decimal
η_{ed}	overall efficiency for a fan with VSD	Expressed as a decimal
η_{es}	overall static efficiency	Expressed as a decimal
η_{esd}	overall static efficiency for a fan with VSD	Expressed as a decimal
η_{opt}	optimum efficiency	Expressed as a decimal
η_r	fan impeller efficiency	Expressed as a decimal
ρ_1	density at fan inlet	kg/m³

NOTE   Efficiency in percent (%) divided by 100 equals the efficiency expressed as a decimal.

5 General information

5.1 General

Fans range from the purpose-built single fan to the series-produced certified ranges manufactured in large quantities. A fan may be a motor attached to a drive system attached to an impeller within an

impeller casing, if so supplemented by a volume control such as a variable speed control or guide vanes (driven fan), see Figure 1.

The variation in design has led to efficiency being defined in a number of ways to suit the demands of the fan type and the market place.
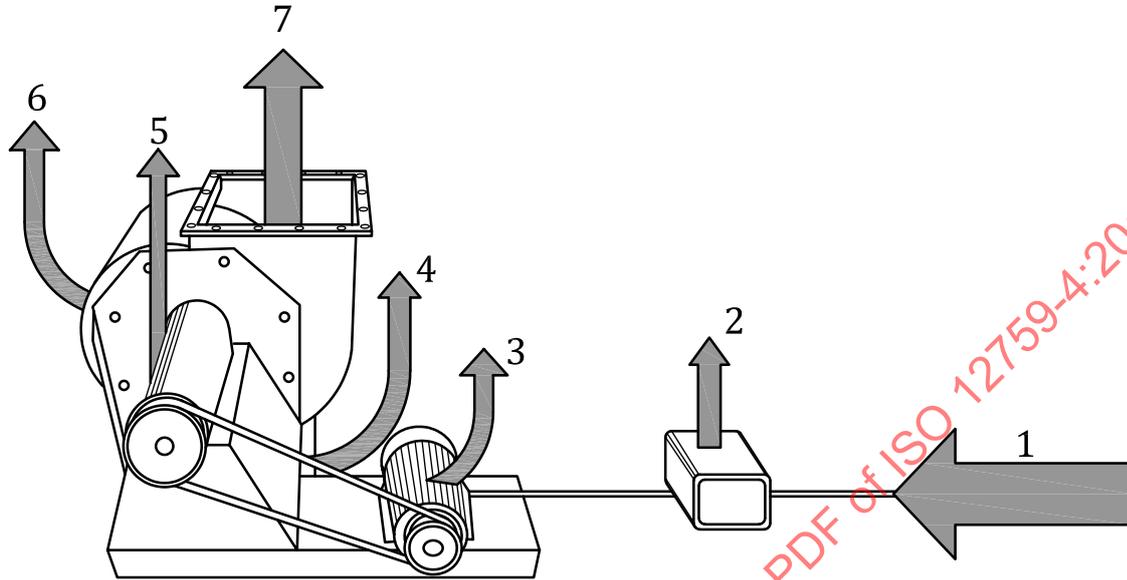
Key

1   electrical input power P_{ed}
2   variable speed device loss (heat)[a]
3   motor losses (heat)
4   belt losses (heat)
5   bearing losses (heat)
6   impeller and casing aerodynamic losses (heat)
7   volume flow and pressure P_u (air power)
[a] The variable speed device might or might not be fitted. See Clause 6.

Figure 1 — Example of a driven fan showing power losses

5.2   Use of installation categories

Fan efficiency ratings are frequently specific to each standardised installation category.

When a fan is designed for a single installation category, its rated efficiency grade shall refer to that particular installation category, and this shall be clearly identified.

When a fan is suitable for use with different installation categories, the fan efficiency grade shall be based on the efficiency ratings referring to the most suitable installation category.

To determine the operating point of the fan, four installation categories are considered, see Figure 2. For details of the required test methods refer to the following subclauses of ISO 5801:

— category A installations – ISO 5801:2017, 6.1;

— category B installations – ISO 5801:2017, 6.2;

— category C installations – ISO 5801:2017, 6.3;

— category D installations – ISO 5801:2017, 6.4.

The standardised installation category used for rating the fan shall be clearly stated (see Annex C).

The motor input power and motor output power shall be measured or determined using methods given in ISO 5801.

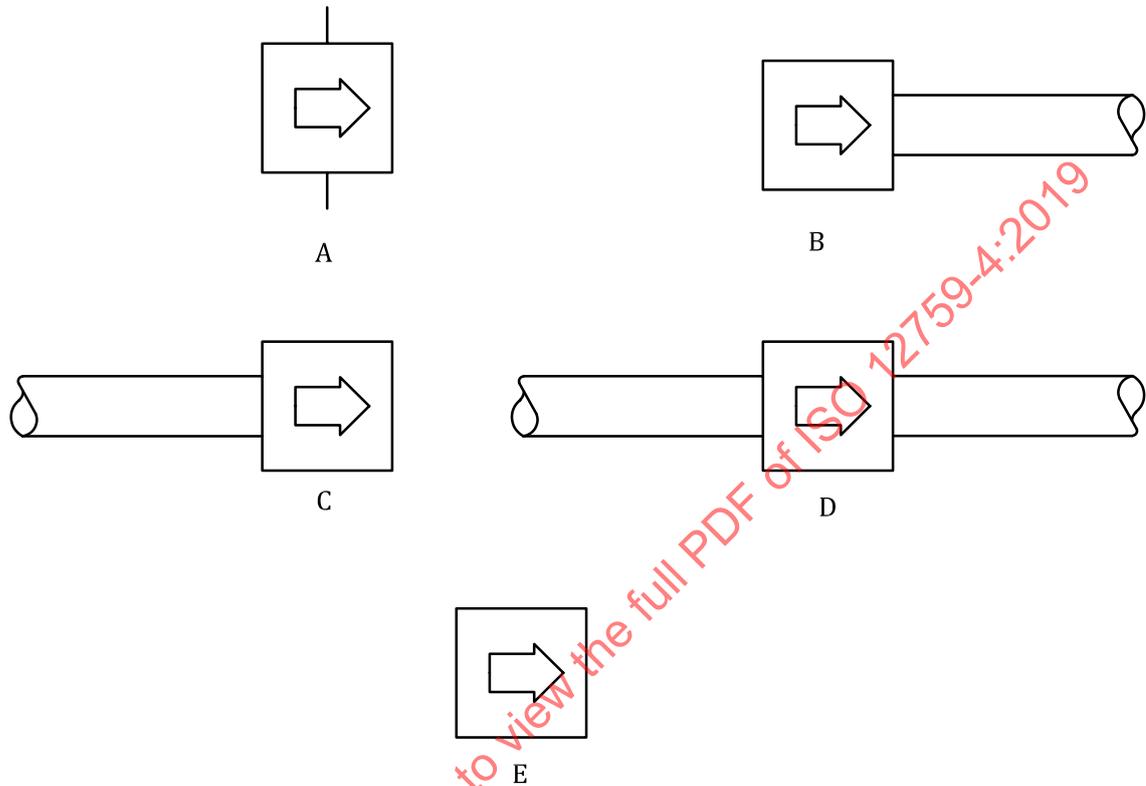Installation category E is not included in this document.

A

B

C

D

E

Figure 2 — Installation categories

5.3 Efficiency calculation

See ISO 5801:2017, 15.2.

For driven fans, where the input power can be determined, the overall efficiency is given by Formula (1) for fans without a variable speed drive and Formula (2) for fans with variable speed drives.

$$\eta_e = P_u / P_e \tag{1}$$

or

$$\eta_{ed} = P_u / P_{ed} \tag{2}$$

The overall static efficiency can be calculated by substituting the static air power into Formulae (1) and (2) so that the overall static efficiency is given by Formula (3) for fans without a variable speed drive and Formula (4) for fans with variable speed drives.

$$\eta_{es} = P_{us} / P_e \tag{3}$$

or

$$\eta_{esd} = P_{us} / P_{ed} \tag{4}$$

5.4 Tolerances

At each stage of the fan design and manufacturing cycle, including conversion from prototype performance data or calculation, and fabrication and testing of a purpose-designed fan, finite uncertainties will prevail and acceptance tolerances shall be applied.

Any test for fan performance is subject to error, and the range within which these testing errors may be expected to lie is defined numerically as the uncertainty of measurement. In addition, the true performance of the fan (if it could be ascertained) would be found to differ from that of another nominally identical fan, owing to inevitable variations in manufacture. The expected range of this manufacturing variation shall be added to the uncertainty of measurement to determine the minimum tolerance required for a performance specification.

For the purposes of this document the tolerances given in ISO 13348:2007, Clauses 5 and 6, shall apply.

6 Ratings

6.1 General

The variation of fan type and drive option leads to efficiency being derived in different ways. For grading purposes, the efficiency for driven fans has been defined as a function of motor input power.

The following is a guide to the optimum efficiency (best efficiency point) levels that are achievable by the fan types addressed by this document. The minimum levels of acceptability are dependent on consultation between regulators and manufacturers' representatives or local legislation where this exists.

The efficiency grade for a fan is based on its performance characteristics at maximum permissible rotational speed to obtain its best efficiency point.

Further information on the subject of fan efficiency can be found in Annexes D and E.

6.2 Driven fans

The efficiency grades for driven fans are shown in Figures 3, 4 and 5. The variation of optimum efficiency and fan motor efficiency grade (FMEG) is shown as a function of input power and design.

In cases where a volume control device is necessary, a variable speed drive is the best option, as it is the most efficient method for adjustment to different operating points. Other options for volume control such as guide vanes or control valves are less efficient.

The FMEG (e.g. FMEG55) of a given fan at its best efficiency point at full speed shall be the value calculated according to Annex A, for the relevant input power.

The curves of FMEGs are based on impeller and motor combinations. If a control device is used then the efficiency data can be revised by the correction values for controls in Annex B, Table B.1.

6.3 Axial, forward curved centrifugal, radial and mixed flow driven fan efficiency grades

Key
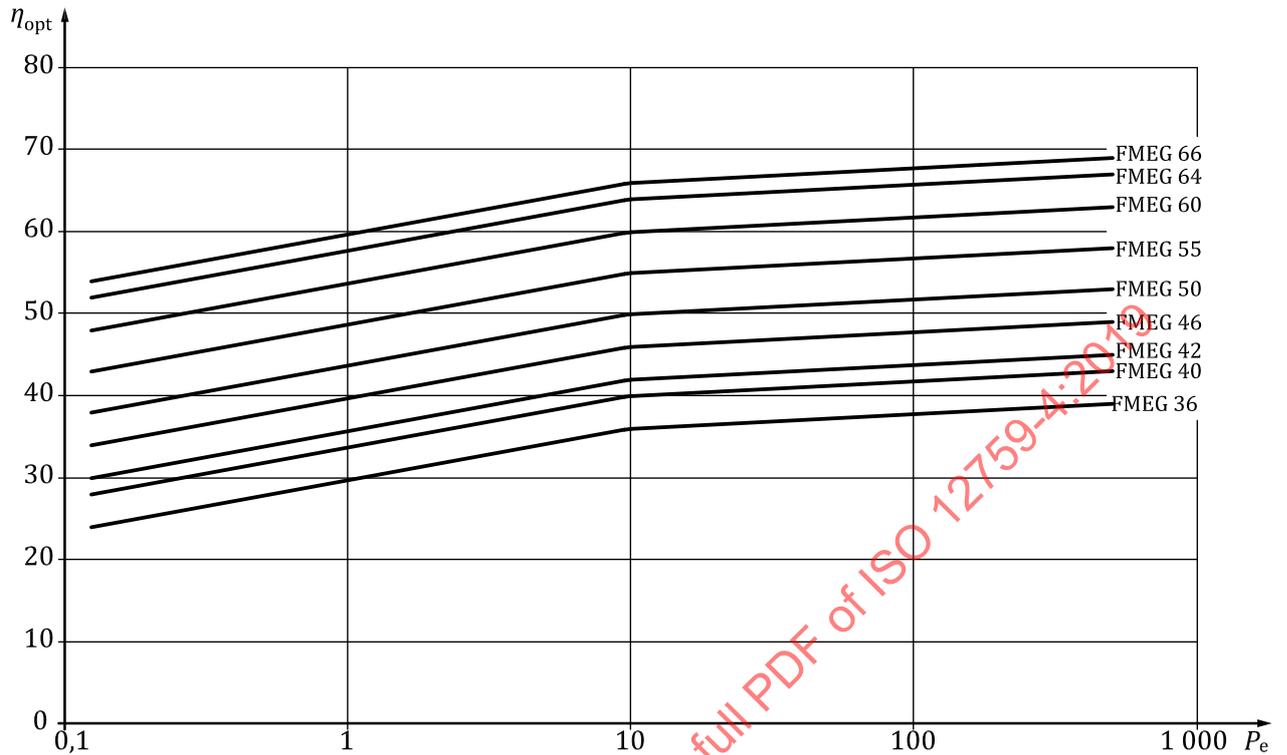
P_e motor input power/kW

η_{opt} optimum efficiency (best efficiency point)/%

Figure 3 — Axial, forward curved centrifugal, radial and mixed flow driven fan efficiency grades

Figure 3 and Table 1 are generated by Formulae (5) to (8).

For input power of less than or equal to 10 kW

Fan and motor:

$$\eta_{opt} = 2{,}74 \times \ln(P_e) - 6{,}33 + N_G \tag{5}$$

Fan and drive/control devices:

$$\eta_{opt} = 2{,}74 \times \ln(P_{ed}) - 6{,}33 + N_G \tag{6}$$

For input power greater than 10 kW

Fan and motor:

$$\eta_{opt} = 0{,}78 \times \ln(P_e) - 1{,}88 + N_G \tag{7}$$

Fan and drive/control devices:

$$\eta_{opt} = 0{,}78 \times \ln(P_{ed}) - 1{,}88 + N_G \tag{8}$$

where

P_e is the input power, in kilowatts;

P_{ed} is the drive/control electrical input power, in kilowatts;

N_G is the grade number (integer) of the FMEG, e.g. N_G = 40 for FMEG40.

Table 1 — Axial, forward curved centrifugal, radial and mixed flow driven fan efficiency grades

Values in %

Efficiency grade	Optimum efficiency (best efficiency point) by input power												
	0,125 kW	0,25 kW	1,1 kW	3,0 kW	4,0 kW	5,5 kW	10 kW	22 kW	75 kW	150 kW	375 kW	450 kW	500 kW
FMEG36	24,0	25,9	29,9	32,7	33,5	34,3	36,0	36,5	37,5	38,0	38,7	38,9	39,0
FMEG40	28,0	29,9	33,9	36,7	37,5	38,3	40,0	40,5	41,5	42,0	42,7	42,9	43,0
FMEG42	30,0	31,9	35,9	38,7	39,5	40,3	42,0	42,5	43,5	44,0	44,7	44,9	45,0
FMEG46	34,0	35,9	39,9	42,7	43,5	44,3	46,0	46,5	47,5	48,0	48,7	48,9	49,0
FMEG50	38,0	39,9	43,9	46,7	47,5	48,3	50,0	50,5	51,5	52,0	52,7	52,9	53,0
FMEG55	43,0	44,9	48,9	51,7	52,5	53,3	55,0	55,5	56,5	57,0	57,7	57,9	58,0
FMEG60	48,0	49,9	53,9	56,7	57,5	58,3	60,0	60,5	61,5	62,0	62,7	62,9	63,0
FMEG64	52,0	53,9	57,9	60,7	61,5	62,3	64,0	64,5	65,5	66,0	66,7	66,9	67,0
FMEG66	54,0	55,9	59,9	62,7	63,5	64,3	66,0	66,5	67,5	68,0	68,7	68,9	69,0

NOTE   For any fan driven by a motor larger than 500 kW the values of the grade limits are the same as for a fan driven by a motor of 500 kW.

6.4 Centrifugal backward bladed fan with and without housing driven fan efficiency grades

Key
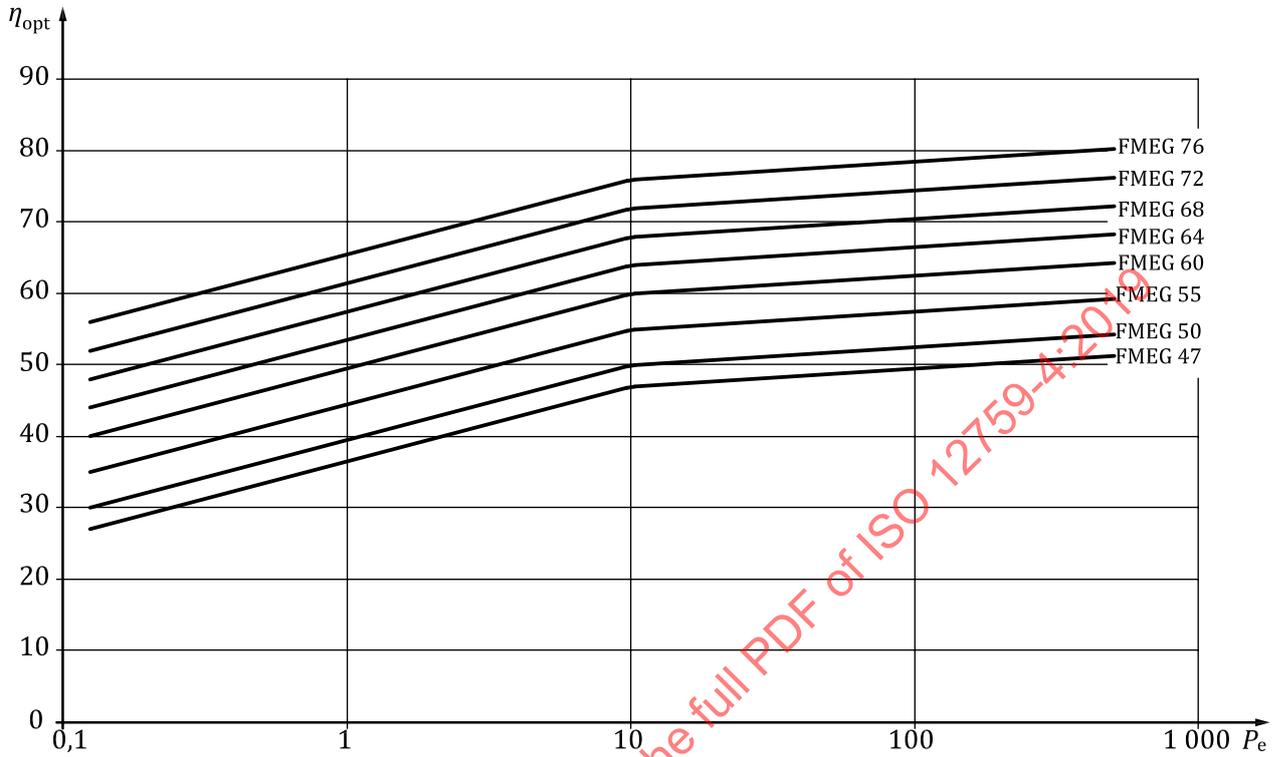
P_e motor input power (kW)

η_{opt} optimum efficiency (best efficiency point) (%)

Figure 4 — Centrifugal backward bladed fan with and without housing driven fan efficiency grades

Figure 4 and Table 2 are generated by Formulae (9) to (12).

For input power of less than or equal to 10 kW

Fan and motor:

$$\eta_{opt} = 4{,}56 \times \ln(P_e) - 10{,}5 + N_G \tag{9}$$

Fan and drive/control devices:

$$\eta_{opt} = 4{,}56 \times \ln(P_{ed}) - 10{,}5 + N_G \tag{10}$$

For input power greater than 10 kW

Fan and motor:

$$\eta_{opt} = 1{,}1 \times \ln(P_e) - 2{,}6 + N_G \tag{11}$$

Fan and drive/control devices:

$$\eta_{opt} = 1{,}1 \times \ln(P_{ed}) - 2{,}6 + N_G \tag{12}$$

where

P_e is the input power, in kilowatts;

P_{ed} is the drive/control electrical input power, in kilowatts;

N_G is the grade number (integer) of the FMEG, e.g. N_G = 50 for FMEG50.

Table 2 — Centrifugal backward bladed fan with and without housing driven fan efficiency grades

Efficiency grade	Optimum efficiency (best efficiency point) by input power												
	0,125 kW	0,25 kW	1,1 kW	3 kW	4 kW	5,5 kW	10 kW	22 kW	75 kW	150 kW	300 kW	375 kW	500 kW
FMEG47	27,0	30,2	36,9	41,5	42,8	44,3	47,0	47,8	49,1	49,9	50,7	50,9	51,2
FMEG50	30,0	33,2	39,9	44,5	45,8	47,3	50,0	50,8	52,1	52,9	53,7	53,9	54,2
FMEG55	35,0	38,2	44,9	49,5	50,8	52,3	55,0	55,8	57,1	57,9	58,7	58,9	59,2
FMEG60	40,0	43,2	49,9	54,5	55,8	57,3	60,0	60,8	62,1	62,9	63,7	63,9	64,2
FMEG64	44,0	47,2	53,9	58,5	59,8	61,3	64,0	64,8	66,1	66,9	67,7	67,9	68,2
FMEG68	48,0	51,2	57,9	62,5	63,8	65,3	68,0	68,8	70,1	70,9	71,7	71,9	72,2
FMEG72	52,0	55,2	61,9	66,5	67,8	69,3	72,0	72,8	74,1	74,9	75,7	75,9	76,2
FMEG76	56,0	59,2	65,9	70,5	71,8	73,3	76,0	76,8	78,1	78,9	79,7	79,9	80,2

NOTE   For any fan driven by a motor larger than 500 kW the values of the grade limits are the same as for a fan driven by a motor of 500 kW.
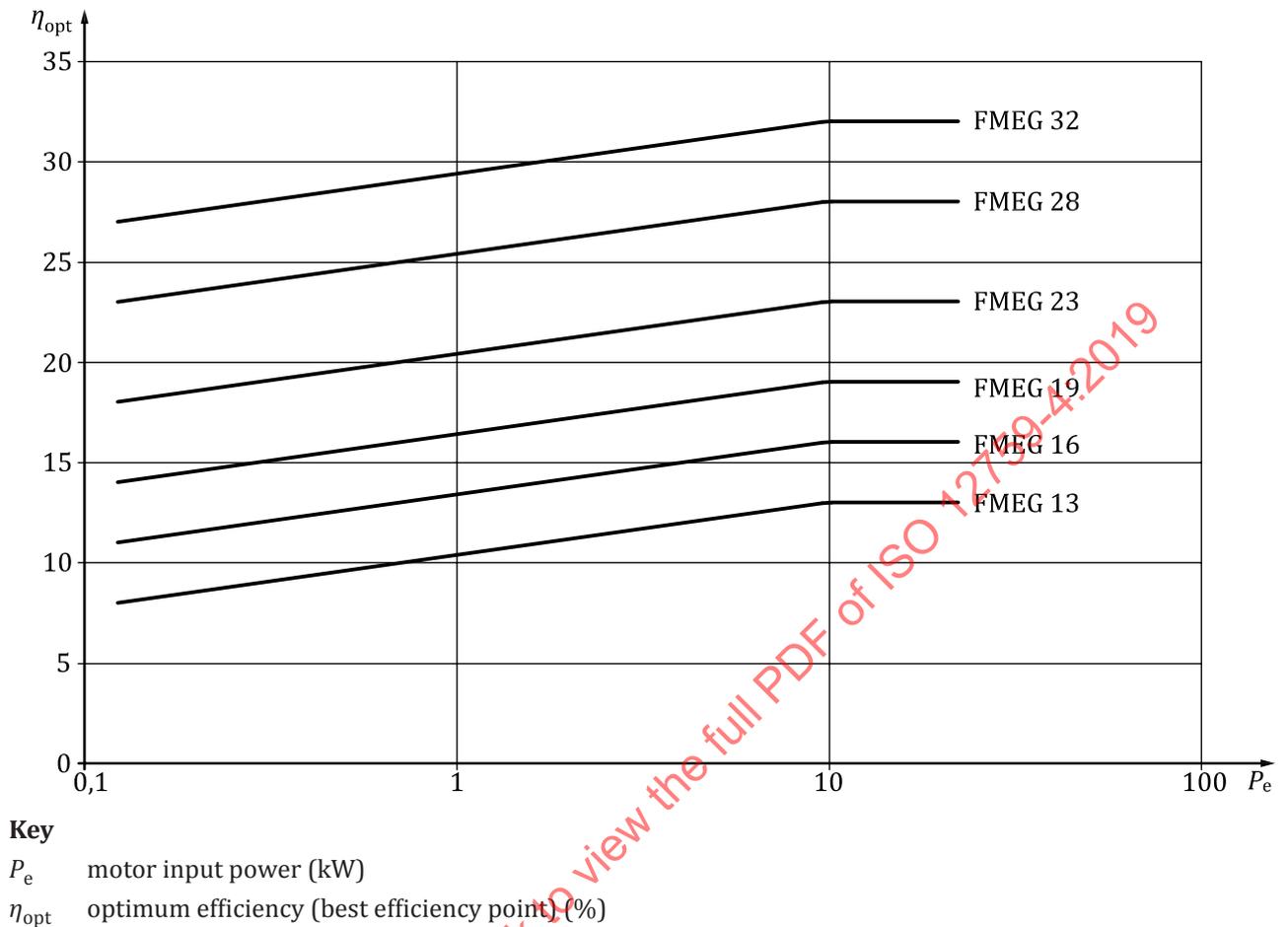
6.5 Cross flow driven fan efficiency grades

Key

P_e motor input power (kW)

η_{opt} optimum efficiency (best efficiency point) (%)

Figure 5 — Cross flow driven fan efficiency grades

Figure 5 and Table 3 are generated by Formulae (13) to (15).

For the input power of less than or equal to 10 kW

Fan and motor:

$$\eta_{opt} = 1{,}14 \times \ln(P_e) - 2{,}6 + N_G \tag{13}$$

Fan and drive/control devices:

$$\eta_{opt} = 1{,}14 \times \ln(P_{ed}) - 2{,}6 + N_G \tag{14}$$

For the input power greater than 10 kW

Fan and motor, and fan, motor and drives:

$$\eta_{opt} = N_G \tag{15}$$

where

P_e is the input power, in kilowatts;

P_{ed} is the drive/control electrical input power, in kilowatts;

N_G is the grade number (integer) of the FMEG, e.g. N_G = 15 for FMEG15.

Table 3 — Cross flow driven fan efficiency grades

Efficiency grade	Optimum efficiency (best efficiency point) by input power												
	0,125 kW	0,25 kW	0,5 kW	0,75 kW	1,1 kW	2,2 kW	3,0 kW	4,0 kW	5,5 kW	7,5 kW	10 kW	15 kW	22 kW
FMEG13	8,0	8,8	9,6	10,1	10,5	11,3	11,7	12,0	12,3	12,7	13,0	13,0	13,0
FMEG16	11,0	11,8	12,6	13,1	13,5	14,3	14,7	15,0	15,3	15,7	16,0	16,0	16,0
FMEG19	14,0	14,8	15,6	16,1	16,5	17,3	17,7	18,0	18,3	18,7	19,0	19,0	19,0
FMEG23	18,0	18,8	19,6	20,1	20,5	21,3	21,7	22,0	22,3	22,7	23,0	23,0	23,0
FMEG28	23,0	23,8	24,6	25,1	25,5	26,3	26,7	27,0	27,3	27,7	28,0	28,0	28,0
FMEG32	27,0	27,8	28,6	29,1	29,5	30,3	30,7	31,0	31,3	31,7	32,0	32,0	32,0

Annex A
(normative)

Examples of applying efficiency lines to driven fans

A.1 Determination of efficiency grade for a driven fan

A.1.1 General

To determine the efficiency grade (FMEG) of a driven fan one of the formulae given below should be applied depending on fan type. The formulae apply to motors up to 500 kW. The calculated value for motors of 500 kW applies to all higher motor ratings.

A.1.2 Axial, forward curved centrifugal, radial and mixed flow driven fans

For motors 125 W < X ≤ 10 kW use Formula (5):

$$\eta_{opt} = 2{,}74 \times \ln\left(P_e\right) - 6{,}33 + N_G$$

For motors 10 kW < X ≤ 500 kW use Formula (7):

$$\eta_{opt} = 0{,}78 \times \ln\left(P_e\right) - 1{,}88 + N_G$$

Where N_G is the integer in the efficiency line designation, for example N_G = 40 for efficiency line FMEG40.

Any efficiency line can be found for lines between those shown in Figure 3. For example for a unit with an input power of 6,2 kW, the line for FMEG42 = 2,74 × ln(P_e) – 6,33 + 42.

A.1.3 Centrifugal backward bladed fan with and without housing driven fan

For motors 125 W < X ≤ 10 kW use Formula (9):

$$\eta_{opt} = 4{,}56 \times \ln\left(P_e\right) - 10{,}5 + N_G$$

For motors 10 kW < X ≤ 500 kW use Formula (11):

$$\eta_{opt} = 1{,}1 \times \ln\left(P_e\right) - 2{,}6 + N_G$$

Where N_G is the integer in the efficiency line designation, for example N_G = 58 for efficiency line FMEG58.

Any efficiency line can be found for lines between those shown in Figure 4. For a unit with an input power of 23,2 kW, the line for FMEG62 = 1,1 × ln(P_e) – 2,6 + 62.

A.1.4 Cross flow fan

For motors 125 W < X ≤ 10 kW use Formula (13):

$$\eta_{opt} = 1,14 \times \ln(P_e) - 2,6 + N_G$$

For motors 10 kW < X ≤ 500 kW use Formula (A.1):

$$\text{Efficiency line} = \eta_{opt} = N_G \tag{A.1}$$

Where N_G is the integer in the efficiency line designation, for example N_G = 13 for efficiency line FMEG13. Any efficiency line can be found for lines between those shown in Figure 5. For example, for a unit with an input power of 2,3 kW the line for FMEG17 = 1,14 × ln(P_e) − 2,6 + 17.

A.2 Calculation of efficiency grades

A.2.1 Centrifugal fan with forward curved impeller

For example, a contract requires an axial fan to exceed a driven fan efficiency line, for an axial fan, of FMEG45. The proposed fan has an air power, P_u, of 0,08 kW, an electrical power input, P_e, of 0,27 kW at its point of optimum efficiency and has been measured using installation category D.

Using Formula (1)

$$\eta_e = P_u / P_e$$

η_e = 0,296

this gives an overall efficiency of 29,6 %.

Applying N_G = 45 from FMEG45 to Formula (5) it is found that the optimum efficiency should be 35,1 % or greater for a power input of 0,27 kW. Therefore, the proposed fan does not meet the minimum criteria for efficiency line FMEG45.

$$\eta_{opt} = 2,74 \times \ln(P_e) - 6,33 + N_G$$

N_G = 45, P_e = 0,27 kW

Therefore, the minimum efficiency is: 2,74 × ln(0,27) − 6,33 + 45 = 0,351 or 35,1 %.

A.2.2 Centrifugal radial (plug) fan

For example, legislation could require a fan to exceed a driven fan efficiency line, for a centrifugal plug fan, of FMEG55. The proposed centrifugal plug fan has an integral variable speed drive and has an air power P_{us} of 1,133 kW, an electrical power input P_{ed} of 1,925 kW at its point of optimum efficiency and has been measured using installation category A.

Using Formula (A.2)

$$\eta_{ed} = (P_{us} / P_{ed}) \times C_c \tag{A.2}$$

= (1,133/1,925) × 1,068 = 0,629,

this gives an overall fan efficiency of 62,9 %.

When using [Formula (10)](#) it is found that the optimum efficiency should be 47,5 % or greater for a power input of 1,925 kW. Therefore, the proposed fan does meet the minimum criteria for efficiency line FMEG55.

$$\eta_{opt} = 4,56 \times \ln(P_{ed}) - 10,5 + N_G$$

$N_G = 55$, $P_{ed} = 1,925$ kW

Therefore, the minimum efficiency is 4,56 × ln(1,925) − 10,5 + 55 = 0,475 or 47,5 %.

Annex B
(informative)

Compensation factors

If a fan is fitted with a variable speed drive then the efficiency of the fan may be adjusted to take into account the energy-saving potential of fitting such a device, the means of adjustment is given in Formula (B.1).

$$\eta_e = (P_u / P_{ed}) \times C_c \tag{B.1}$$

where

η_e is the overall efficiency;

P_u is the fan air power, in kilowatts;

P_{ed} is the drive/control electrical input power, in kilowatts;

C_c is the compensation factor based on drive/control input power, see Table B.1.

Table B.1 — Compensation factor for fans fitted with variable speed drives

Drive/control electrical input power	Compensation factor (C_c)
$P_{ed} < 5$ kW	$-0{,}03 \times \ln(P_{ed}) + 1{,}088$
$P_{ed} \geq 5$ kW	$1{,}04$

Annex C
(informative)

The variation of fan performance between installation categories

There can be a significant difference of results in performance measurements between the installation categories. It is therefore important for the person selecting the fan, the end user and/or legislator to understand which installation category is being stated.

The installation categories are devised to give a good indication as to how the fan may perform in a particular application. For example, an axial fan on a refrigeration condenser operates in a condition close to free inlet and free outlet conditions and therefore installation category A would be appropriate. Installation category D is for applications where there is a duct fitted on the inlet and outlet and would give an incorrect indication of performance when the fan is applied to a refrigeration condenser.

A further example is a radial (plug) fan used in an air handling unit (AHU). This operates in close to free inlet and outlet conditions and measurements taken according to installation category A will be appropriate. If a duct is connected to the fan inlet inside the AHU, then installation category C will be more appropriate.

An axial fan tested according to installation category D will give a higher efficiency value than one measured to installation category A. A plug fan measured according to category C will give a higher efficiency value than according to category A.

Legislators could use this document by clearly stating the installation category when setting the minimum efficiency levels, for example:

— axial fan according to installation category A – minimum efficiency level FMEGxx;

— axial fan according to installation category B – minimum efficiency level FMEGxx;

— axial fan according to installation category C – minimum efficiency level FMEGxx;

— axial fan according to installation category D – minimum efficiency level FMEGxx;

— axial fan according to installation category E – see ISO 12759-5 jet fans for FMEGxx.