INTERNATIONAL STANDARD

ISO 12759-2

First edition
2019-03

Fans — Efficiency classification for fans —

Part 2: Standard losses for drive components

Ventilateurs — Classification du rendement des ventilateurs —

Partie 2: Détermination à charge partielle

Reference number
ISO 12759-2:2019(E)

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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 12759-2, together with ISO 12759-1 and ISO 12759-3 to ISO 12759-6, 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.

Introduction

This document 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 document offers a standardized method to estimate fan system performance by modelling commonly used components. Calculations reported in accordance with this document offer fan users a tool to compare alternative fan system configurations in a consistent and uniform manner.

Fans — Efficiency classification for fans —

Part 2:
Standard losses for drive components

1 Scope

This document establishes a classification for fan efficiency. It applies to all electric-motor-driven fan systems that utilize a specific combination of components as defined below:

a) fan airflow performance determined in accordance with an accepted performance standard;

b) polyphase induction motors with nominal motor efficiency specified in this document;

NOTE 1 Other types of motors are explicitly excluded.

c) pulse-width modulated variable frequency drives (VFDs) for use with single motors;

NOTE 2 Single VFDs that service multiple, parallel fan motors are excluded.

d) mechanical power transmissions that utilize V-belts, flat belts, cog belts or couplings.

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, *Fans — Performance testing using standardized airways*

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

ANSI/AMCA 230, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*

ANSI/AMCA 260, *Laboratory Methods of Testing Induced Flow Fans for Rating*

3 Terms, definitions and symbols

3.1 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/

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

3.1.2
V-belt transmission
drive belts having a substantially trapezoidal cross section that uses sheaves (pulleys) having smooth contact surfaces

Note 1 to entry: 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.

3.1.3
synchronous belt 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

Note 1 to entry: These belts are sometimes called timing or toothed belts.

3.2 Symbols

Symbol	Description	Unit
η_{T}	Transmission efficiency (see NOTE)	dimensionless
η_{m}	Motor efficiency	dimensionless
η_{c}	Motor controller efficiency	dimensionless
η_{es}	Overall static efficiency	dimensionless
η_{e}	Overall efficiency	dimensionless
η_{mc}	Combined motor and motor control efficiency	dimensionless
η_{mrat}	Motor rated full load efficiency	dimensionless
P_{e}	Fan system input power	kW
P_{a}	Fan input power	kW
P_{u}	Fan output power	kW
P_{mo}	Motor output power	kW
P_{mrat}	Motor rated output power (nameplate)	kW
P_{mi}	Motor input power	kW
P_{ci}	Motor controller input power	kW
P_{co}	Motor controller output power	kW
P_{crat}	Motor controller rated output power	kW
P_{ti}	Transmission input power	kW
P_{to}	Transmission output power	kW
L_{m}	Motor load ratio	dimensionless
L_{c}	Motor controller load ratio	dimensionless
N	Fan speed	1/min
f_{L}	Mains line frequency	Hz
η_{s}	Fan static efficiency	dimensionless
η	Fan efficiency	dimensionless
n	Number of poles in induction motor	dimensionless
NOTE The symbol η_{T}, transmission efficiency, should not be confused with η, fan efficiency.		

4 Fan system efficiency calculations

4.1 General

This clause describes the calculations required to estimate the extended fan system input power and overall extended fan system efficiency. Calculations start with the fan performance and then progress to each fan system component. See Annex A.

4.2 Components

4.2.1 Fan

Fan input power, P_a, is the starting point for the system calculation. Fan performance shall be determined in accordance with an accepted performance standard such as ISO 5801, ANSI/AMCA 230 or ANSI/AMCA 260. The fan laws and ISO 13348 shall be used to determine fan performance at operating conditions other than those tested. For calculation of fan system input power (P_e), performance variables P_a and N shall be available for the desired fan operating point. To calculate the overall fan system efficiency, η_s or η are also required.

4.2.2 Power transmission

The power transmission is a component of the fan system that transfers power from the motor to the fan, often involving a speed change.

4.2.2.1 V-belt transmission

The efficiency of a V-belt transmission is calculated as

$$\eta_T = 0{,}96\left(\frac{P_a}{P_a + 1{,}64}\right)^{0{,}05}$$

4.2.2.2 Synchronous belt transmission

The efficiency of a synchronous belt transmission is calculated as

P_a <= 1 kW, η_T = 0,94

1 kW < P_a < 5 kW, η_T = 0,01 P_a + 0,93

P_a = > 5 kW, η_T = 0,98

4.2.2.3 Coupling

Efficiency of coupling can be assumed to be

— η_T = 0,98 for coupling with elastomeric or rubber drive;

— η_T = 0,99 for coupling with steel disc/diaphragm/spring drive.

Consult coupling manufacturer for fluid/powder/magnetic and other slip type couplings.

4.2.2.4 No power transmission

If there is no power transmission and the fan impeller is directly coupled to the motor, then

η_T = 1

4.2.3 Motor and controller

The following subclauses detail the calculations for various motor and motor/controller combinations. Fan systems incorporating components other than those described are not covered by this document.

4.2.3.1 Regulated polyphase induction motors controlled by a VFD

Calculations presented are limited to certain regulated polyphase induction motors driven by pulse-width modulated VFDs at the drive's rated nameplate voltage.

The motor and component parameters P_{mrat}, n, f, the motor enclosure type and P_{crat} shall be known.

The calculation combines both the motor and VFD efficiency into a single value. This is valid only if the VFD is sized for the intended motor. VFDs with capacity greater than the motor rating are not considered. It is assumed that the VFD is operating with a constant volts per hertz ratio for drive frequencies less than line frequency, and at constant voltage above the line frequency. Other control algorithms are not covered by this document.

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

$$P_{mo} = P_a / \eta_T$$

The combined motor and VFD efficiency is calculated as

$$\eta_{mc} = \eta_{mrat} \left(\frac{aL_m}{b + L_m} + cL_m^2 \right) \left(\frac{dL_c}{e + L_c} + fL_c \right)$$

where

η_{mrat} is the rated full load efficiency declared by the manufacturer on the rating plate (rated efficiency) as defined in IEC 60034-30-1; some regions may require defined minimum efficiencies such that η_{mrat} is, as a minimum, a regulated value (examples of regulated values for the U.S., Europe and China can be found respectively in Annex B, Annex C and Annex D);

L_m is the motor load ratio calculated by $L_m = P_{mo}/P_{mrat}$;

a and *b* are coefficients obtained from Annex E or Annex F, depending on the applicable motor configuration.

The coefficient *c* is calculated as

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

The coefficients *d*, *e* and *f* are found in Annex G or Annex H, depending on the applicable VFD configuration. The load ratio for the VFD is calculated by

$$L_c = \frac{P_{mo}}{\eta_m P_{crat}}$$

where P_{crat} is the output capacity of the VFD.

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

$$L_c = n_m \left(P_{mo} \right) / \left(\eta_m P_{crat} \right)$$

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

The VFD and motor models used for this calculation are based on constant volts per hertz ratio operation. 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 shall ensure that selected components have sufficient capacity and are configured to produce the desired results. The purpose is to provide a consistent calculation procedure for comparing a pool of competing fan systems when actual test data are not available.

4.2.3.2 Regulated polyphase induction motors powered direct on line (DOL)

Calculations presented are limited to certain regulated polyphase induction motors directly driven from the line voltage and line frequency at the motor's rated nameplate voltage.

The motor parameters P_{mrat}, n, f, and the motor enclosure type shall be known.

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

$$P_{mo} = P_a/\eta_T$$

The motor efficiency is calculated by

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

where

η_{mrat} is the rated full load efficiency declared by the manufacturer on the rating plate (rated efficiency) as defined in IEC 60034-30-1; some regions may require defined minimum efficiencies such that η_{mrat} is, as a minimum, a regulated value (examples of regulated values for the U.S., Europe and China can be found respectively in Annex B, Annex C and Annex D);

L_m is the motor load ratio calculated by

$$L_m = P_{mo}/P_{mrat} \quad [0 < L_m < 1{,}5]$$

The coefficients a and b are obtained from Annex I or Annex J, depending on the applicable motor configuration.

The coefficient c is calculated exactly as

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

Calculations at motor load ratios greater than one are valid up to L_m = 1,5. Users shall ensure that specific motors are capable of operation above the nameplate rating.

4.3 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

$$P_e = \frac{P_a}{\eta_T \eta_m}$$

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

$$P_e = \frac{P_a}{\eta_T \eta_{mc}}$$

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

$$\eta_e = \eta \eta_T \eta_m$$

or

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

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

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

or

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

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

5 Reporting of results

When reporting input fan system power or overall fan system efficiency, the following information shall be included:

a) overall fan system efficiency rounded to the nearest integer or fan system input power;

b) fan operating point:

   1) flow;

   2) fan pressure or fan static pressure;

   3) shaft power;

   4) fan speed;

   5) inlet density;

   6) test standard used to obtain items 1, 2, 3, 4, 5;

   7) electric input power;

c) motor nameplate power, number of poles (or synchronous speed), enclosure, type of motor; full load motor efficiency;

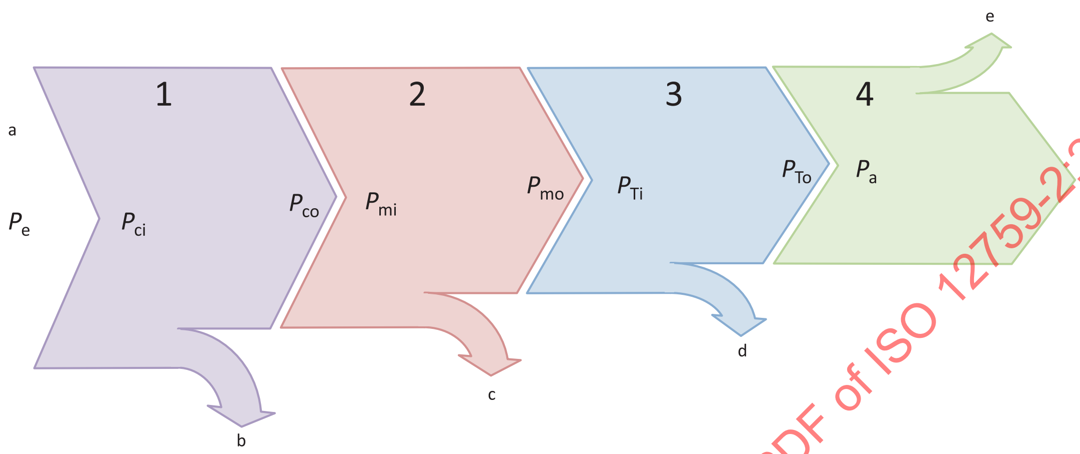
d) input power line frequency;

e) transmission type;

f) motor controller rated output.

Annex A
(informative)

Fan system power losses



Key

1 control
2 motor
3 transmission
4 fan

a Input power.
b Control losses.
c Motor losses.
d Transmission losses.
e Fan losses.
f Fan air power.

Annex B
(informative)

EPCA nominal motor efficiency (60 Hz motors)

Taken from Reference [9].

Nominal motor power (hp)	IC01 (ODP)				IC411 (TEFC)			
	2 pole	4 pole	6 pole	8 pole	2 pole	4 pole	6 pole	8 pole
	%	%	%	%	%	%	%	%
1	77,0	85,5	82,5	75,5	77,0	85,5	82,5	75,5
1,5	84,0	86,5	86,5	77,0	84,0	86,5	87,5	78,5
2	85,5	86,5	87,5	86,5	85,5	86,5	88,5	84,0
3	85,5	89,5	88,5	87,5	86,5	89,5	89,5	85,5
5	86,5	89,5	89,5	88,5	88,5	89,5	89,5	86,5
7,5	88,5	91,0	90,2	89,5	89,5	91,7	91,0	86,5
10	89,5	91,7	91,7	90,2	90,2	91,7	91,0	89,5
15	90,2	93,0	91,7	90,2	91,0	92,4	91,7	89,5
20	91,0	93,0	92,4	91,0	91,0	93,0	91,7	90,2
25	91,7	93,6	93,0	91,0	91,7	93,6	93,0	90,2
30	91,7	94,1	93,6	91,7	91,7	93,6	93,0	91,7
40	92,4	94,1	94,1	91,7	92,4	94,1	94,1	91,7
50	93,0	94,5	94,1	92,4	93,0	94,5	94,1	92,4
60	93,6	95,0	94,5	93,0	93,6	95,0	94,5	92,4
75	93,6	95,0	94,5	94,1	93,6	95,4	94,5	93,6
100	93,6	95,4	95,0	94,1	94,1	95,4	95,0	93,6
125	94,1	95,4	95,0	94,1	95,0	95,4	95,0	94,1
150	94,1	95,8	95,4	94,1	95,0	95,8	95,8	94,1
200	95,0	95,8	95,4	94,1	95,4	96,2	95,8	94,5
250	95,0	95,8	95,8	95,0	95,8	96,2	95,8	95,0
300	95,4	95,8	95,8		95,8	96,2	95,8	
350	95,4	95,8	95,8		95,8	96,2	95,8	
400	95,8	95,8			95,8	96,2		
450	96,2	96,2			95,8	96,2		
500	96,2	96,2			95,8	96,2		

Annex C
(informative)

IEC 60034-30-1 nominal motor efficiency at 50 Hz

C.1 IE1 and IE2 at 50 Hz

Nominal motor power (kW)	IE1				IE2			
	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
1,5	77,2	77,2	75,2	70,2	81,3	82,8	79,8	74,1
2,2	79,7	79,7	77,7	74,2	83,2	84,3	81,8	77,6
3	81,5	81,5	79,7	77,0	84,6	85,5	83,3	80,0
4	83,1	83,1	81,4	79,2	85,8	86,6	84,6	81,9
5,5	84,7	84,7	83,1	81,4	87,0	87,7	86,0	83,8
7,5	86,0	86,0	84,7	83,1	88,1	88,7	87,2	85,3
11	87,6	87,6	86,4	85,0	89,4	89,8	88,7	86,9
15	88,7	88,7	87,7	86,2	90,3	90,6	89,7	88,0
18,5	89,3	89,3	88,6	86,9	90,9	91,2	90,4	88,6
22	89,9	89,9	89,2	87,4	91,3	91,6	90,9	89,1
30	90,7	90,7	90,2	88,3	92,0	92,3	91,7	89,8
37	91,2	91,2	90,8	88,8	92,5	92,7	92,2	90,3
45	91,7	91,7	91,4	89,2	92,9	93,1	92,7	90,7
55	92,1	92,1	91,9	89,7	93,2	93,5	93,1	91,0
75	92,7	92,7	92,6	90,3	93,8	94,0	93,7	91,6
90	93,0	93,0	92,9	90,7	94,1	94,2	94,0	91,9
110	93,3	93,3	93,3	91,1	94,3	94,5	94,3	92,3
132	93,5	93,5	93,5	91,5	94,6	94,7	94,6	92,6
160	93,8	93,8	93,8	91,9	94,8	94,9	94,8	93,0
200 – 1 000	94,0	94,0	94,0	92,5	95,0	95,1	95,0	93,5

C.2 IE3 and IE4 at 50 Hz

Nominal motor power (kW)	IE3				IE4			
	2 pole	4 pole	6 pole	8 pole	2 pole	4 pole	6 pole	8 pole
	%	%	%	%	%	%	%	%
1,1	82,7	84,1	81,0	77,7	85,2	87,2	84,5	80,8
1,5	84,2	85,3	82,5	79,7	86,5	88,2	85,9	82,6
2,2	85,9	86,7	84,3	81,9	88,0	89,5	87,4	84,5
3	87,1	87,7	85,6	83,5	89,1	90,4	88,6	85,9
4	88,1	88,6	86,8	84,8	90,0	91,1	89,5	87,1
5,5	89,2	89,6	88,0	86,2	90,9	91,9	90,5	88,3
7,5	90,1	90,4	89,1	87,3	91,7	92,6	91,3	89,3
11	91,2	91,4	90,3	88,6	92,6	93,3	92,3	90,4
15	91,9	92,1	91,2	89,6	93,3	93,9	92,9	91,2
18,5	92,4	92,6	91,7	90,1	93,7	94,2	93,4	91,7
22	92,7	93,0	92,2	90,6	94,0	94,5	93,7	92,1
30	93,3	93,6	92,9	91,3	94,5	94,9	94,2	92,7
37	93,7	93,9	93,3	91,8	94,8	95,2	94,5	93,1
45	94,0	94,2	93,7	92,2	95,0	95,4	94,8	93,4
55	94,3	94,6	94,1	92,5	95,3	95,7	95,1	93,7
75	94,7	95,0	94,6	93,1	95,6	96,0	95,4	94,2
90	95,0	95,2	94,9	93,4	95,8	96,1	95,6	94,4
110	95,2	95,4	95,1	93,7	96,0	96,3	95,8	94,7
132	95,4	95,6	95,4	94,0	96,2	96,4	96,0	94,9
160	95,6	95,8	95,6	94,3	96,3	96,6	96,2	95,1
200	95,8	96,0	95,8	94,6	96,5	96,7	96,3	95,4
250	95,8	96,0	95,8	94,6	96,5	96,7	96,5	95,4
315 - 1 000	95,8	96,0	95,8	94,6	96,5	96,7	96,6	95,4

C.3 IE1 and IE2 at 60 Hz

Nominal motor power (kW)	IE1				IE2			
	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
1,5	81,0	81,5	77,0	77,0	840	84,0	86,5	82,5
2,2	81,5	83,0	78,5	78,0	85,5	87,5	87,5	84,0
3,7	84,5	85,0	83,5	80,0	87,5	87,5	87,5	85,5
5,5	86,0	87,0	85,0	84,0	88,5	89,5	89,5	85,5
7,5	87,5	87,5	86,0	85,0	89,5	89,5	89,5	88,5
11	87,5	88,5	89,0	87,5	90,2	91,0	90,2	88,5
15	88,5	89,5	89,5	88,5	90,2	91,0	90,2	89,5
18,5	89,5	90,5	90,2	88,5	91,0	92,4	91,7	89,5
22	89,5	91,0	91,0	90,2	91,0	92,4	91,7	91,0
30	90,2	91,7	91,7	90,2	91,7	93,0	93,0	91,0
37	91,5	92,4	91,7	91,0	92,4	93,0	93,0	91,7
45	91,7	93,0	91,7	91,0	93,0	93,6	93,6	91,7
55	92,4	93,0	92,1	91,5	93,0	94,1	93,6	93,0
75	93,0	93,2	93,0	92,0	93,6	94,5	94,1	93,0
90	93,0	93,2	93,0	92,5	94,5	94,5	94,1	93,6
110	93,0	93,5	94,1	92,5	94,5	95,0	95,0	93,6
150	94,1	94,5	94,1	92,5	95,0	95,0	95,0	93,6
185	94,1	94,5	94,1	92,5	95,4	95,0	95,0	93,6
220 up to 335	94,1	94,5	94,1	92,5	95,4	95,4	95,0	93,6
375 up to 1 000	94,1	94,5	94,1	92,5	95,4	95,8	95,0	94,1

C.4 IE3 and IE4 at 60 Hz

Nominal motor power (kW)	IE3				IE4			
	2 pole	4 pole	6 pole	8 pole	2 pole	4 pole	6 pole	8 pole
	%	%	%	%	%	%	%	%
1,1	84,0	86,5	87,5	78,5	85,5	875	88,5	81,5
1,5	85,5	86,5	88,5	84,0	86,5	88,5	89,5	85,5
2,2	86,5	89,5	89,5	85,5	88,5	91,0	90,2	87,5
3,7	88,5	89,5	89,5	86,5	89,5	91,0	90,2	88,5
5,5	89,5	91,7	91,0	86,5	90,2	92,4	91,7	88,5
7,5	90,2	91,7	91,0	89,5	91,7	92,4	92,4	91,0
11	91,0	92,4	91,7	89,5	92,4	93,6	93,0	91,0
15	91,0	93,0	91,7	90,2	92,4	94,1	93,0	91,7
18,5	91,7	93,6	93,0	90,2	93,0	94,5	94,1	91,7
22	91,7	93,6	93,0	91,7	93,0	94,5	94,1	93,0
30	92,4	94,1	94,1	91,7	93,6	95,0	95,0	93,0
37	93,0	94,5	94,1	92,4	94,1	95,4	95,0	93,6
45	93,6	95,0	94,5	92,4	94,5	95,4	95,4	93,6
55	93,6	95,4	94,5	93,6	94,5	95,8	95,4	94,5
75	94,1	95,4	95,0	93,6	95,0	96,2	95,8	94,5
90	95,0	95,4	95,0	94,1	95,4	96,2	95,8	95,0
110	95,0	95,8	95,8	94,1	95,4	96,2	96,2	95,0
150	95,4	96,2	95,8	94,5	95,8	96,5	96,2	95,4
185	95,8	96,2	95,8	95,0	96,2	96,5	96,2	95,4
220	95,8	96,2	95,8	95,0	96,2	96,8	96,5	95,4
250 up to 1 000	95,8	96,2	95,8	95,0	96,2	96,8	96,5	95,8

Annex D
(informative)

Nominal motor efficiency according to Reference [7] for China

Nominal 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 E
(normative)

Horsepower rated polyphase induction motor performance constants when fed from VFD

Nominal motor power (hp)	2 pole		4 pole		6 and 8 pole	
	a	*b*	*a*	*b*	*a*	*b*
1	1,029 06	0,017 01	1,037 44	0,033 37	1,090 59	0,064 57
1,5	1,029 98	0,016 10	1,038 12	0,031 20	1,084 84	0,059 03
2	1,030 90	0,015 20	1,038 80	0,029 02	1,079 10	0,053 49
3	1,032 73	0,013 38	1,040 16	0,024 67	1,067 60	0,042 40
5	1,036 41	0,009 75	1,042 88	0,015 96	1,044 61	0,020 24
7,5	1,034 89	0,008 92	1,040 77	0,014 46	1,042 43	0,017 98
10	1,033 38	0,008 08	1,038 66	0,012 96	1,040 25	0,015 72
15	1,030 35	0,006 41	1,034 43	0,009 96	1,035 88	0,011 21
20	1,027 32	0,004 74	1,030 21	0,006 96	1,031 52	0,006 70
25	1,026 54	0,004 76	1,028 82	0,006 42	1,029 77	0,006 22
30	1,025 75	0,004 78	1,027 42	0,005 88	1,028 03	0,005 75
40	1,024 18	0,004 81	1,024 64	0,004 79	1,024 54	0,004 80
50	1,022 61	0,004 85	1,021 85	0,003 70	1,021 06	0,003 84
60	1,022 26	0,004 49	1,021 00	0,003 50	1,020 57	0,003 99
75	1,021 74	0,003 95	1,019 72	0,003 20	1,019 85	0,004 20
100	1,020 87	0,003 06	1,017 58	0,002 69	1,018 64	0,004 55
125	1,019 97	0,002 99	1,017 25	0,002 86	1,019 56	0,004 59
150	1,019 07	0,002 93	1,016 92	0,003 03	1,020 47	0,004 62
200	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
250	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
300	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
350	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
400	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
450	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
500	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68

Annex F
(normative)

Kilowatt rated polyphase induction motor performance constants when fed from VFD

Nominal motor power (kW)	2 pole		4 pole		6 and 8 pole	
	a	*b*	*a*	*b*	*a*	*b*
1	1,029 68	0,016 39	1,037 91	0,031 89	1,086 68	0,060 80
1,1	1,029 93	0,016 15	1,038 09	0,031 31	1,085 14	0,059 31
1,5	1,030 92	0,015 18	1,038 82	0,028 97	1,078 97	0,053 37
2,2	1,032 64	0,013 47	1,040 09	0,024 89	1,068 19	0,042 97
3	1,034 61	0,011 53	1,041 55	0,020 22	1,055 86	0,031 08
3,7	1,036 33	0,009 82	1,042 83	0,016 14	1,045 07	0,020 68
4	1,036 19	0,009 63	1,042 57	0,015 75	1,044 30	0,019 91
5,5	1,034 97	0,008 96	1,040 88	0,014 54	1,042 54	0,018 10
7,5	1,033 35	0,008 06	1,038 61	0,012 93	1,040 20	0,015 68
11	1,030 50	0,006 50	1,034 65	0,010 12	1,036 10	0,011 44
15	1,027 31	0,004 74	1,030 18	0,006 95	1,031 48	0,006 69
18,5	1,026 57	0,004 76	1,028 87	0,006 44	1,029 84	0,006 24
22	1,025 83	0,004 77	1,027 56	0,005 93	1,028 21	0,005 80
30	1,024 14	0,004 81	1,024 58	0,004 77	1,024 47	0,004 78
37	1,022 67	0,004 85	1,021 96	0,003 75	1,021 20	0,003 88
45	1,022 25	0,004 48	1,020 97	0,003 49	1,020 56	0,003 99
55	1,021 78	0,004 00	1,019 83	0,003 22	1,019 91	0,004 18
75	1,020 85	0,003 05	1,017 58	0,002 69	1,018 66	0,004 55
90	1,020 13	0,003 00	1,017 31	0,002 83	1,019 40	0,004 58
110	1,019 16	0,002 94	1,016 95	0,003 01	1,020 38	0,004 61
132	1,018 10	0,002 86	1,016 56	0,003 21	1,021 46	0,004 65
150	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
160	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
185	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
200	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
220	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
250	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
300	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
330	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68
375	1,017 27	0,002 80	1,016 26	0,003 36	1,022 30	0,004 68