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)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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, $\eta_T = 0{,}94$

1 kW $< P_a <$ 5 kW, $\eta_T = 0{,}01\ P_a + 0{,}93$

$P_a = >$ 5 kW, $\eta_T = 0{,}98$

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

$\eta_T = 1$

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

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

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.