

INTERNATIONAL STANDARD

NORME INTERNATIONALE



GROUP ENERGY EFFICIENCY PUBLICATION

PUBLICATION GROUPEE SUR L'EFFICACITE ENERGÉTIQUE

**Adjustable speed electrical power drive systems (PDS) –
Part 9-2: Ecodesign for motor systems – Energy efficiency determination and
classification**

**Entraînements électriques de puissance (EPS) à vitesse variable –
Partie 9-2: Écoconception des systèmes moteurs – Détermination et
classification de l'efficacité énergétique**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications preview. With a subscription you will always have access to up-to-date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



GROUP ENERGY EFFICIENCY PUBLICATION
PUBLICATION GROUPEE SUR L'EFFICACITE ENERGÉTIQUE

**Adjustable speed electrical power drive systems (PDS) –
Part 9-2: Ecodesign for motor systems – Energy efficiency determination and
classification**

**Entraînements électriques de puissance (PDS) à vitesse variable –
Partie 9-2: Écoconception des systèmes moteurs – Détermination et
classification de l'efficacité énergétique**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.130.01; 29.160.30; 29.200

ISBN 978-2-8322-7576-4

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	9
INTRODUCTION.....	11
1 Scope.....	12
2 Normative references	13
3 Terms, definitions and symbols.....	14
3.1 Terms and definitions.....	14
3.2 Symbols.....	18
4 PDS efficiency, reference CDM (RCDM) and reference motor (RM).....	26
4.1 General.....	26
4.2 Reference operating points of the PDS, RCDM, RM and associated losses	27
4.3 Combining PDS losses with the driven equipment – Workflow for the semi-analytical model (SAM)	29
4.4 IE Classes of line-fed motors	31
4.5 IE Classes of converter-fed motors	31
4.6 IE Classes of frequency converters (complete drive modules – CDM).....	31
4.7 IES Classes of a PDS	32
4.8 Consistency of IE and IES Classes	32
4.9 Determination of the IES class of a PDS by application of "reference" and "test" devices and guidance for the providers.....	33
5 Determination of CDM, motor and PDS loss by calculation.....	34
5.1 General.....	34
5.2 CDM losses	35
5.2.1 General procedure and definition of the CDM and the test load	35
5.2.2 Overall CDM losses	37
5.2.3 Loss determination of CDMs composed by combination of submodules	38
5.2.4 Validation of loss calculation method	40
5.3 Motor losses	40
5.3.1 General	40
5.3.2 Additional harmonic losses of three-phase asynchronous motors fed by a CDM	41
5.3.3 Motor loss data.....	41
5.4 Power drive system (PDS) losses	41
5.4.1 PDS losses.....	41
5.4.2 PDS losses at different switching frequencies.....	43
5.5 PDS losses for regenerative operation	44
5.6 Losses of motor starters	44
6 Losses of IE and IES Classes.....	44
6.1 General.....	44
6.2 CDM	45
6.3 Correction factors for CDMs with modified functionality.....	47
6.3.1 General	47
6.3.2 Correction factors	48
6.3.3 Reference losses and loss determination concept for CDMs and SDOMs with multiple AC outputs	49
6.4 Motor	51
6.5 PDS.....	51
7 Loss determination	52

7.1	General.....	52
7.2	Type testing of CDM or SDM for IE classification	53
7.3	Type testing of PDS for IES classification	54
7.4	Determination of losses by calculation	54
7.4.1	CDM or SDM losses by calculation	54
7.4.2	PDS losses by calculation.....	55
7.5	Determination of losses by measurement, Input-output method.....	55
7.5.1	Instrumentation.....	55
7.5.2	Test conditions	56
7.5.3	Input-output measurement of CDM losses	57
7.5.4	Input-output measurement of SDIM losses.....	59
7.5.5	Input-output measurement of SDOM losses	61
7.5.6	Input-output measurement of PDS losses	62
7.6	Calorimetric measurement of CDM losses.....	63
7.7	Flowcharts for test procedures	64
8	Requirements for the user's documentation	67
8.1	General.....	67
8.2	Information for selection	68
8.3	Information for determination of energy efficiency classification	68
8.4	Information on the determination of additional energy losses and part load conditions	68
8.4.1	General	68
8.4.2	Losses in part load conditions.....	68
8.4.3	Losses of accessories and options	69
8.4.4	Losses in stand-by mode	69
8.4.5	Regenerative mode	69
8.4.6	Characteristics and correction factors.....	69
Annex A (informative)	Losses of RCDM and example of IES class limit determination.....	70
A.1	Relative loss tables.....	70
A.2	Calculation of relative losses for IES classes	71
A.2.1	General	71
A.2.2	Determination of CDM relative losses	71
A.2.3	Determination of motor relative losses	72
A.2.4	Summation of PDS relative losses	72
Annex B (informative)	Description of the elements of an extended product using PDS with regard to their impact on losses.....	73
B.1	General.....	73
B.2	Losses in the mains cabling and feeding section.....	73
B.3	Input filter	75
B.3.1	High frequency EMI filter	75
B.3.2	Low frequency line harmonics filter.....	75
B.4	Input converter.....	76
B.4.1	General	76
B.4.2	Diode rectifier	76
B.4.3	Active infeed converter	76
B.4.4	Power factor of the input converter	78
B.4.5	Sub drive input module (SDIM)	79
B.5	DC link.....	79
B.6	Output inverter	80

B.6.1	General	80
B.6.2	Sub drive output model (SDOM)	81
B.7	Output filter and motor cables	81
B.7.1	General	81
B.7.2	Sine wave filters	82
B.7.3	dV/dt filters and motor chokes	83
B.7.4	High frequency EMI motor filters	83
B.7.5	Motor cables	83
B.8	Motor	83
B.9	Mechanical load	83
B.10	Control and standby losses	84
B.11	Cooling losses	84
B.11.1	Primary cooling losses	84
B.11.2	Secondary cooling losses	84
Annex C (informative)	Mathematical model for CDM losses	85
C.1	General	85
C.2	Output inverter losses	85
C.2.1	General	85
C.2.2	Transistor on state losses	85
C.2.3	Freewheeling diode on state losses	86
C.2.4	Transistor switching losses	86
C.2.5	Freewheeling diode switching losses	87
C.2.6	Output inverter total losses	88
C.3	Input converter losses	88
C.3.1	Active infeed converter	88
C.3.2	Diode rectifier	88
C.4	Input choke losses	89
C.5	DC link losses	90
C.6	Current conductor losses	90
C.7	Control and standby losses	91
C.8	Cooling loss factor	91
C.9	Other CDM losses	91
Annex D (informative)	Converter topology	92
D.1	General	92
D.2	Voltage source output inverter topologies different from those mathematically described in Clause C.2	92
D.3	Voltage source input converter topologies different from those mathematically described in Clause C.3	92
D.4	CDM topologies different from voltage source type	93
Annex E (informative)	Interpolation of motor losses and motor current	94
E.1	General	94
E.2	Relative and reference values	94
E.3	Motor connections and operating ranges	95
E.4	Interpolation of motor losses	96
E.5	Interpolation of motor current	99
E.6	Determination of the interpolation coefficients	101
E.6.1	General	101
E.6.2	Analytical determination	101
E.6.3	Numerical determination	103

E.7	Achievable accuracies	104
E.8	Typical induction motor efficiency	104
Annex F (informative) Application example for loss calculations of a CDM and a PDS		110
F.1	General.....	110
F.2	CDM loss determination	110
F.2.1	General	110
F.2.2	Loss determination by two-dimensional interpolation of losses of neighbouring loss points	111
F.2.3	Loss determination by the mathematical model described in Annex C.....	114
F.3	Loss determination of the motor	116
F.4	Loss determination of the PDS.....	117
F.5	Determination of part load factors for SDIMs.....	118
F.6	Application examples of reference losses and efficiency classes for modified functionality	119
F.6.1	General	119
F.6.2	Example 1 – IE classification of an SDIM.....	119
F.6.3	Example 2 – IE classification of an SDOM	119
F.6.4	Example 3 – IE classification of a CDM with regenerative capability and sinewave output filter.....	120
Annex G (informative) Uncertainty of loss determination method		122
G.1	General.....	122
G.2	Calculation of uncertainty at randomly occurring errors	122
G.3	Comparison of uncertainties for different loss determination methods	122
Annex H (informative) Calorimetric measurement for CDM losses		123
H.1	General.....	123
H.2	Calorimeter with two chambers with air as a cooling medium	123
H.3	Calorimeter with one chamber with air as a cooling medium	124
H.4	Calorimeter with liquid as a cooling medium.....	125
Annex I (informative) PDS loss calculation above rated speed and torque		126
I.1	General.....	126
I.2	Operating points above rated torque	126
I.3	Operating points above rated speed.....	126
I.3.1	General	126
I.3.2	Dependency of motor losses on the CDM performance	126
I.3.3	Dependency of CDM on the motor performance	127
I.3.4	PDS loss calculation in the field weakening range up to 200 % of rated speed	127
Annex J (informative) Explanation for correction factors for the reference losses in Table 8		128
J.1	General.....	128
J.2	CDM	128
J.2.1	CDM without regenerative capability	128
J.2.2	CDM with regenerative capability	129
J.2.3	CDM with $DF_U \leq 10\%$	130
J.2.4	CDM with a rated input voltage ≤ 250 V (three phase)	130
J.2.5	CDM with single phase input.....	130
J.3	SDIM and SDOM	131
J.3.1	General	131
J.3.2	SDIM without regenerative capability	131

J.3.3	SDIM with regenerative capability	131
J.3.4	SDOM.....	132
J.4	CDM, SDIM and SDOM with external cooling	132
J.5	CDM and SDOM with multiple AC outputs	132
	Bibliography.....	133
	Figure 1 – Example of complete drive module (CDM) built by sub drive modules (SDM)	15
	Figure 2 – Illustration of the extended product with included motor system	16
	Figure 3 – Torque-speed-characteristic of servo PDS	17
	Figure 4 – Illustration of the operating points (shaft speed, torque) for the determination of relative losses of the power drive system (PDS)	22
	Figure 5 – Illustration of the operating points (shaft speed, torque) for the determination of relative losses of the reference motor (RM).....	28
	Figure 6 – Illustration of the operating points (relative motor stator frequency, relative torque current) for the determination of losses of the reference complete drive module (RCDM)	29
	Figure 7 – Illustration of the workflow to determine the energy efficiency index (EEI) of an extended product	30
	Figure 8 – Illustration how to combine different data sources to determine the energy efficiency index (EEI) of an extended product	31
	Figure 9 – Metrical relation	32
	Figure 10 – Guidance for CDM and motor providers for the usage of "test" and "reference" devices to determine the IE/IES classes	34
	Figure 11 – Illustration of a typical CDM and test load	35
	Figure 12 – Example of relative losses $p_{L,CDM}$ of the 9,95 kVA RCDM	38
	Figure 13 – Example of the relative power losses of PDS as function of speed and torque	43
	Figure 14 – Example representation of the relative power losses versus switching frequency of a 7,5 kW to 11 kW PDS	43
	Figure 15 – Example of a CDM with resistor for dissipating generated power.....	44
	Figure 16 – Illustration of IE classes for a CDM.....	47
	Figure 17 – Topology of a CDM with multiple AC outputs	50
	Figure 18 – Losses of CDM or SDM are provided as the sum of the determined losses plus the uncertainty of the determination method	53
	Figure 19 – Input-output measurement setup for determination of CDM losses	58
	Figure 20 – Order of CDM measurements from [1] to [8]	58
	Figure 21 – Input-output measurement setup for determination of SDIM losses	60
	Figure 22 – Input-output measurement setup for determination of SDOM losses	61
	Figure 23 – Input-output measurement setup for PDS losses	62
	Figure 24 – Order of PDS measurements from [1] to [8]	63
	Figure 25 – Calorimetric measurement setup for determining CDM losses	64
	Figure 26 – Determination of IE classification for CDM and loss determination for part load operating points	65
	Figure 27 – Determination of IES classification for PDS and loss determination for part load operating points	66
	Figure B.1 – Overview of the extended product and energy flow	73
	Figure B.2 – Equivalent circuit of the mains and mains cabling	74

Figure B.3 – Illustration of a single-phase line harmonics filter	75
Figure B.4 – PDS with a diode rectifier input converter	76
Figure B.5 – PDS with a standard AIC input converter	77
Figure B.6 – PDS with a F3E-AIC input converter without line choke.....	77
Figure B.7 – Typical waveform of a diode rectifier line current	78
Figure B.8 – DC link circuit	79
Figure B.9 – DC link circuit with additional DC chokes	80
Figure B.10 – Output inverter of the PDS	81
Figure B.11 – Motor cable and optional output filter of the PDS	82
Figure B.12 – Typical waveform of inverter output voltage and motor voltage when using a sine wave output filter.....	82
Figure E.1 – Normalized torque and speed of ranges a and b for connection Y or D	95
Figure E.2 – Normalized torque and speed of ranges a and b for connection Y → D	96
Figure E.3 – Normalized torque and speed of range a for connection Y → YY	96
Figure E.4 – Normalized losses of an exemplary motor in connection Y or D	97
Figure E.5 – Normalized losses of an exemplary motor in connection Y → D	97
Figure E.6 – Normalized losses of an exemplary motor in connection Y → YY	98
Figure E.7 – Efficiency map of the exemplary motor in connection Y or D	98
Figure E.8 – Efficiency map of the exemplary motor in connection Y → D	99
Figure E.9 – Efficiency map of the exemplary motor in connection Y → YY	99
Figure E.10 – Line-current of the exemplary motor in connection Y or D	100
Figure E.11 – Line-current of the exemplary motor in connection Y → D	100
Figure E.12 – Line-current of the exemplary motor in connection Y → YY	101
Figure E.13 – Standardized operating points of IEC 60034-2-3	102
Figure F.1 – Segments of operating points.....	110
Figure F.2 – Two-dimensional interpolation.....	111
Figure H.1 – One-step calorimetric measurement setup for comparative loss measurement (CDM and heating resistor are loaded simultaneously).....	123
Figure H.2 – Two-step calorimetric measurement setup for comparative loss measurement (CDM and heating resistor are not loaded simultaneously).....	124
Figure H.3 – Liquid pool calorimetric measurement setup for CDM loss measurement.....	125
Table 1 – Minimum test load currents at different points of operation	36
Table 2 – Test load displacement factor between fundamental output current and fundamental output voltage at different points of operation	36
Table 3 – Example of relative losses of the 400 V/9,95 kVA reference CDM at the operating points described in Figure 6	38
Table 4 – Active SDIM power ratio to be used for loss calculation at the CDM operating points.....	40
Table 5 – Reference parameter for Formula (13).....	42
Table 6 – Relative losses of the 400 V/7,5 kW PDS	42
Table 7 – Reference CDM losses for class IE1 definition	45
Table 8 – Correction factors for different CDM, SDIM and SDOM characteristics	49
Table 9 – Information requirements.....	67

Table A.1 – Relative losses (%) of reference CDMs (IE1) at different power ratings at the operating points described in Figure 6	70
Table A.2 – Relative losses of the 9,95 kVA CDM according to Table A.1	71
Table B.1 – Typical values of λ for different input converter topologies	78
Table C.1 – Reference parameters for Formula (C.1).....	85
Table C.2 – Variables for Formula (C.1).....	86
Table C.3 – Reference parameters for Formula (C.2).....	86
Table C.4 – Reference parameters for Formula (C.3).....	87
Table C.5 – Reference parameters for Formula (C.4).....	87
Table C.6 – Reference parameters for Formula (C.6).....	89
Table C.7 – Variables for Formula (C.6).....	89
Table C.8 – Reference parameters for Formula (C.7).....	89
Table C.9 – Reference parameters for Formula (C.8).....	90
Table C.10 – Reference parameters for Formula (C.9).....	90
Table C.11 – Reference parameter for Formula (5).....	91
Table C.12 – Reference parameter for Formula (C.10).....	91
Table E.1 – Normative operating points of IEC 60034-2-3.....	101
Table E.2 – Interpolation coefficients of typical 4-pole IE2 induction machines	105
Table E.3 – Interpolation coefficients of typical 2-pole IE2 induction machines	106
Table E.4 – Interpolation coefficients of typical 4-pole IE3 induction machines	107
Table E.5 – Interpolation coefficients of typical 4-pole IE4 induction machines	108
Table E.6 – Interpolation coefficients of typical 4-pole IE5 induction machines	109
Table F.1 – Relative losses of a 400 V/9,95 kVA example CDM (IE1) at the predefined operating points	111
Table F.2 – Parameters of the example CDM	115
Table F.3 – Results of the CDM calculation according to the mathematical model.....	116
Table F.4 – Comparison of different loss evaluation methods.....	116
Table F.5 – Loss data of the 7,5 kW example motor.....	116
Table F.6 – Calculated partial factors for SDIM part load operation points	118

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS (PDS) –**Part 9-2: Ecodesign for motor systems –
Energy efficiency determination and classification**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 61800-9-2 has been prepared by subcommittee 22G: Adjustable speed electric drive systems (PDS), of IEC technical committee 22: Power electronic systems and equipment. It is an International Standard.

It has the status of a group energy efficiency publication in accordance with IEC Guide 118.

This second edition cancels and replaces the first edition published in 2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Additional IES Classes defined to IES5;
- b) Removed reference motor loss data and now point to IEC 60034-30-2;

- c) Expanded and modified factors in Clause 6 for CDMs;
- d) Annex C is now the Mathematical Model for CDM Losses;
- e) Moved the mathematical model for the CDM to Annex C;
- f) Added Sub Drive Input Module and Sub Drive Output Modules to Annex B;
- g) Annex D is now the Converter Topology (old Annex C);
- h) Annex E is now the Interpolation of Motor Losses (Old Annex D);
- i) Annex E expanded to include various motor connections and updated interpolation method;
- j) New Annex E for determination of Interpolation Coefficients;
- k) Annex F is the old Annex E;
- l) New Annex J Explanation of Correction Factors for the Reference Losses in Table 8.

The text of this International Standard is based on the following documents:

Draft	Report on voting
22G/475/FDIS	22G/478/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61800 series, published under the general title *Adjustable speed electrical power drive systems (PDS)*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This part of IEC 61800 has been developed to allow evaluation of power losses of SDMs (sub drive modules), CDMs (complete drive modules) and PDSs (power drive systems).

The requirements for measuring energy efficiency of motors with non-sinusoidal supply are under the responsibility of IEC/TC 2 and will be published under the IEC 60034 series.

IEC SC 22G includes the standardization task force for dealing with this topic. It has close collaboration with several other technical committees (for example, IEC TC 2, IEC SC 121A, ISO/TC 115, ISO/TC 117, ISO/TC 118, CEN/TC 197) in order to provide a comprehensive standard for energy efficiency and ecodesign requirements.

IEC SC 22G maintains responsibility for all relevant aspects in the field of energy efficiency and ecodesign requirements for power electronics, switchgear, control gear and power drive systems and their industrial applications.

The IEC 61800 series does not deal with mechanical engineering components.

NOTE 1 Geared motors (motors with directly adapted gearboxes) are treated like power drive systems (converter plus motor). See IEC 60034-30-1 for classification of the losses of a geared motor. The efficiency classes of gearboxes as individual components are under consideration.

IEC 61800-9-2 is a subpart of the IEC 61800 series, which has the following structure:

- Part 1: General requirements – Rating specifications for low voltage adjustable speed DC power drive systems
- Part 2: General requirements – Rating specifications for adjustable speed AC power drive systems
- Part 3: EMC requirements and specific test methods
- Part 5: Safety requirements
- Part 6: Guide for determination of types of load duty and corresponding current ratings
- Part 7: Generic interface and use of profiles for power drive systems
- Part 8: Specification of voltage on the power interface
- Part 9: Ecodesign for motor systems

Some parts are further subdivided into several subparts, published either as International Standards or as Technical Specifications or Technical Reports and will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61800-9-2).

NOTE 2 It is understood that Formula (13) is for Direct-on-Line motors. Formula (13) will be modified in the next amendment to account for Variable Frequency Drive motors.

NOTE 3 A new figure will be developed to demonstrate the use of a star point for measuring the converter phase voltages to determine the $\cos\phi_i$ for each phase in 7.5.3.1.

ADJUSTABLE SPEED ELECTRICAL POWER DRIVE SYSTEMS (PDS) –

Part 9-2: Ecodesign for motor systems – Energy efficiency determination and classification

1 Scope

This part of IEC 61800 specifies energy efficiency indicators of power electronics (complete drive modules (CDM), input or output sub drive modules (SDM), power drive systems (PDS) and motor starters, all used for motor driven equipment.

This document is a group energy efficiency publication according to IEC Guide 119 and specifies the methodology for the determination of losses of the complete drive module (CDM), the sub drive module (SDM), the power drive system (PDS) and the motor system.

It defines IE and IES classes, their limit values and provides test procedures for the classification of the overall losses of the motor system.

Furthermore, this document proposes a methodology for the implementation of the best energy efficiency solution of drive systems. This depends on the architecture of the motor driven system, on the speed/torque profile and on the operating points over time of the driven load equipment. It provides a link for the energy efficiency evaluation and classification of the extended product.

The methodology of the extended product approach and the semi analytical models are defined in IEC 61800-9-1.

The structure of this document is as follows:

- the losses of standardized PDS, standardized reference CDM (RCDM) and the mathematical model for their calculation are given and classified;
- the reference motor (RM) and the reference CDM (RCDM) are defined. They are used for determining the efficiency class of a PDS if either the physical motor or physical CDM is unknown;
- the requirements for the determination of the losses of a physical PDS and a physical CDM including correction factors for other types of CDM, not defined as RCDM or SDM, are given and compared to the IES class limits and the RCDM;
- the requirements for type testing and user documentation are given;
- some exemplary losses of an overall system are illustrated in annexes;
- information about system and drive topologies are given in annexes.

Specific data for the RCDM and RM, limits for the PDS and IE/IES classes are given for low voltage (100 V up to and equal to 1 000 V), single axis AC/AC power drive systems with three-phase motors. Geared motors are treated as standard motors when motor and gearbox can be separated. A methodology is given in addition how this reference data can also be applied to other topologies like AC/DC or DC/AC converters.

All provided reference data is derived from PDS with induction motors. They can be used for various types of PDS with other types of motors as well, for example but not limited to, electronically commutated motors (ECM), permanent magnet motors (PM) or synchronous reluctance motors (SYN-RM), and line-start permanent magnet motors (LSPM).