

Test method, marking requirements, and energy efficiency levels for three-phase induction motors



Legal Notice for Standards

Canadian Standards Association (operating as “CSA Group”) develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document’s fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party’s intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document’s compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group’s and/or others’ intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by treaty or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way, or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.



Standards Update Service

CSA C390:22

October 2022

Title: *Test method, marking requirements, and energy efficiency levels for three-phase induction motors*

To register for e-mail notification about any updates to this publication

- go to www.csagroup.org/store/
- click on **Product Updates**

The **List ID** that you will need to register for updates to this publication is **130 85**.

If you require assistance, please e-mail techsupport@csagroup.org or call 416-747-2233.

Visit CSA Group's policy on privacy at www.csagroup.org/legal to find out how we protect your personal information.

Canadian Standards Association (operating as “CSA Group”), under whose auspices this National Standard has been produced, was chartered in 1919 and accredited by the Standards Council of Canada to the National Standards system in 1973. It is a not-for-profit, nonstatutory, voluntary membership association engaged in standards development and certification activities.

CSA Group standards reflect a national consensus of producers and users — including manufacturers, consumers, retailers, unions and professional organizations, and governmental agencies. The standards are used widely by industry and commerce and often adopted by municipal, provincial, and federal governments in their regulations, particularly in the fields of health, safety, building and construction, and the environment.

More than 10 000 members indicate their support for CSA Group’s standards development by volunteering their time and skills to Committee work.

CSA Group offers certification and testing services in support of and as an extension to its standards development activities. To ensure the integrity of its certification process, CSA Group regularly and continually audits and inspects products that bear the CSA Group Mark.

In addition to its head office and laboratory complex in Toronto, CSA Group has regional branch offices in major centres across Canada and inspection and testing agencies in fourteen countries. Since 1919, CSA Group has developed the necessary expertise to meet its corporate mission: CSA Group is an independent service organization whose mission is to provide an open and effective forum for activities facilitating the exchange of goods and services through the use of standards, certification and related services to meet national and international needs.

For further information on CSA Group services, write to
CSA Group
178 Rexdale Boulevard
Toronto, Ontario, M9W 1R3
Canada

A National Standard of Canada is a standard developed by a Standards Council of Canada (SCC) accredited Standards Development Organization, in compliance with requirements and guidance set out by SCC. More information on National Standards of Canada can be found at www.scc.ca.

SCC is a Crown corporation within the portfolio of Innovation, Science and Economic Development (ISED) Canada. With the goal of enhancing Canada’s economic competitiveness and social well-being, SCC leads and facilitates the development and use of national and international standards. SCC also coordinates Canadian participation in standards development, and identifies strategies to advance Canadian standardization efforts.

Accreditation services are provided by SCC to various customers, including product certifiers, testing laboratories, and standards development organizations. A list of SCC programs and accredited bodies is publicly available at www.scc.ca.

Standards Council of Canada
600-55 Metcalfe Street
Ottawa, Ontario, K1P 6L5
Canada



La norme nationale du Canada n'est disponible qu'en anglais.

Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users to judge its suitability for their particular purpose.

**A trademark of the Canadian Standards Association, operating as “CSA Group”*

National Standard of Canada

CSA C390:22

***Test method, marking requirements,
and energy efficiency levels for
three-phase induction motors***



*®A trademark of the Canadian Standards Association,
operating as "CSA Group"*



*Published in October 2022 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3*

*To purchase standards and related publications, visit our Online Store at www.csagroup.org/store/
or call toll-free 1-800-463-6727 or 416-747-4044.*

*ICS 29.160.30
ISBN 978-1-4883-4495-4*

*© 2022 Canadian Standards Association
All rights reserved. No part of this publication may be reproduced in any form whatsoever
without the prior permission of the publisher.*

Contents

Technical Committee on Industrial Equipment	3
Subcommittee on the Performance of Three-Phase Induction Motors	5
Preface	7
1 Scope	9
1.1 Application	9
1.2 Terminology	9
1.3 SI units	9
2 Reference publications	9
3 Definitions and symbols	10
3.1 Definitions	10
3.2 Symbols	12
4 General	15
5 General test requirements — Measurements	15
5.1 Unit of measure	15
5.2 Power supply	15
5.3 Instrument selection	15
5.4 Instrument transformers	16
5.5 Voltages	16
5.6 Currents	16
5.7 Power	16
5.7.1 General	16
5.7.2 Input power	16
5.7.3 Output power	16
5.8 Error in measurements	17
5.8.1 General	17
5.8.2 Power	17
5.8.3 Voltage and current	17
5.8.4 Torque	17
5.8.5 Temperature	17
5.8.6 Winding resistance	17
5.8.7 Motor speed	17
5.8.8 Frequency	17
6 Efficiency requirements	17
6.1 General	17
6.2 Efficiency at rated voltages, rated frequencies, and rated output powers not covered by Clause 6.1	18
6.3 Efficiency with auxiliary devices	18
7 Test method	18

7.1	Test measurements	18
7.1.1	General	18
7.1.2	Temperature measurement	18
7.1.3	Heat-run test	19
7.1.4	Load test	20
7.1.5	Dynamometer correction test	20
7.1.6	No-load input power stabilization	20
7.1.7	No-load test	21
7.2	Calculations	21
7.2.1	Calculation of temperature rise by resistance ($t_{res\ hr}$)	21
7.2.2	Calculation of stator core and windage and friction losses	21
7.2.3	Calculation of load losses	24
7.2.4	Load loss corrections	25
7.2.5	Output power correction [$P_{corr\ out\ lt(i)}$]	26
7.2.6	Calculation of efficiency [$Eff_{lt(i)}$]	27
7.2.7	Efficiency interpolation	27

8 Marking 27

9 Determining nominal efficiency 27

Annex A (informative)	— Guidelines for determining energy efficiency and information to be recorded	42
Annex B (informative)	— Linear regression analysis	43
Annex C (normative)	— Procedure for correction of dynamometer torque readings	44
Annex D (informative)	— Harmonic voltage factor (HVF)	47
Annex E (informative)	— Bibliography	48

Technical Committee on Industrial Equipment

M. Zeller	BC Hydro, Vancouver, British Columbia, Canada <i>Category: User Interest/Regulatory Authority</i>	<i>Chair</i>
C. Benedetti	Hydro-Québec, Montréal, Québec, Canada <i>Category: User Interest/Regulatory Authority</i>	<i>Vice-Chair</i>
R. P. de Lhorbe	Independent Consultant, North Vancouver, British Columbia, Canada <i>Category: Producer Interest</i>	<i>Vice-Chair</i>
P. Angers	Concordia University, Montréal, Québec, Canada <i>Category: General Interest</i>	
M. Ciulei	Enbridge Pipelines, Edmonton, Alberta, Canada	<i>Non-voting</i>
A. J. Cordova	V.J. Pamensky Canada Inc., Toronto, Ontario, Canada <i>Category: Producer Interest</i>	
J. V. Feldman	Independent Electricity System Operator (IESO), Toronto, Ontario, Canada	<i>Non-voting</i>
D. R. Friesen	Midium Energy, Winnipeg, Manitoba, Canada <i>Category: General Interest</i>	
P. Gallant	Natural Resources Canada, Ottawa, Ontario, Canada	<i>Non-voting</i>
A. Howse	Ontario Ministry of Energy, Northern Development and Mines, Toronto, Ontario, Canada	<i>Non-voting</i>
S. Krsikapa	Ontario Ministry of Energy, Toronto, Ontario, Canada <i>Category: User Interest/Regulatory Authority</i>	

S. Mostafaei	Danfoss Drives Canada, Oakville, Ontario, Canada	<i>Non-voting</i>
A. Orumwense	Natural Resources Canada, Ottawa, Ontario, Canada <i>Category: User Interest/Regulatory Authority</i>	
C. Perrett	Efficiency Manitoba, Winnipeg, Manitoba, Canada	<i>Non-voting</i>
C. D. Pitis	ELEN-MECH. Consulting Inc., Vancouver, British Columbia, Canada <i>Category: General Interest</i>	
P. Vinayagamoorthy	3M Canada, Brockville, Ontario, Canada <i>Category: Producer Interest</i>	
L. Contasti	CSA Group, Toronto, Ontario, Canada	<i>Project Manager</i>

Subcommittee on the Performance of Three-Phase Induction Motors

D. R. Friesen	Meridium Energy, Winnipeg, Manitoba, Canada	<i>Chair</i>
P. Angers	Concordia University, Montréal, Québec, Canada	<i>Acting Vice-Chair</i>
T. Evans	Underwriters Laboratories Inc., Toronto, Ontario, Canada	
A. Hauer	ebm-papst Inc., Farmington, Connecticut, USA	
M. Ishlove	V.J. Pamensky Canada Inc., Toronto, Ontario, Canada	
M. Leibowitz	National Electrical Manufacturers Association (NEMA), Rosslyn, Virginia, USA	
J. Li	Ontario Ministry of Energy, Toronto, Ontario, Canada	
W. E. Lockley	Lockley Engineering Ltd., Calgary, Alberta, Canada	
R. McElveen	ABB Inc., Greenville, South Carolina, USA	
L. Murray	Nidec Motor Corp., St. Louis, Missouri, USA	
A. Orumwense	Natural Resources Canada, Ottawa, Ontario, Canada	
C. Pitis	ELEN-MECH. Consulting Inc., Vancouver, British Columbia, Canada	
S. Ruffing	Nidec Motor Corporation, St. Louis, Missouri, USA	

M. Zeller

BC Hydro,
Vancouver, British Columbia, Canada

L. Contasti

CSA Group,
Toronto, Ontario, Canada

Project Manager

Preface

This is the fifth edition of CSA C390, *Test method, marking requirements, and energy efficiency levels for three-phase induction motors*. It supersedes the previous editions published in 2010, 1998, 1993, and 1985 under the title *Energy Efficiency Test Methods for Three-Phase Induction Motors*, and CSA Preliminary Standards C390.1 and C390.2, published in 1982.

This new edition was revised to harmonize the Standard to the extent possible with the relevant IEC and IEEE Standards. Major changes to this edition include the following:

- a) revising the Scope to remove an upper limit in the size of the motor that could be tested;
- b) revising the definition for thermal equilibrium;
- c) revising energy efficiency levels and tables;
- d) revising Annex C to include mandatory language; and
- e) replacing the former Annex D, which had contained Canadian energy efficiency regulatory information.

CSA acknowledges that the development of this Standard was made possible, in part, by the financial support of BC Hydro, the Canadian Electricity Association (CEA), Hydro-Québec, the Independent Electricity System Operator (IESO), Manitoba Hydro, and Natural Resources Canada.

This Standard is considered suitable for use for conformity assessment within the stated scope of the Standard.

This Standard was prepared by the Subcommittee on the Performance of Three-Phase Induction Motors, under the jurisdiction of the Technical Committee on Industrial Equipment and the Strategic Steering Committee on Performance, Energy Efficiency, and Renewables, and has been formally approved by the Technical Committee.

This Standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

Notes:

- 1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
- 2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
- 3) *This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*
- 4) *To submit a request for interpretation of this Standard, please send the following information to inquiries@csagroup.org and include “Request for interpretation” in the subject line:*
 - a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
 - b) *provide an explanation of circumstances surrounding the actual field condition; and*
 - c) *where possible, phrase the request in such a way that a specific “yes” or “no” answer will address the issue.*

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.
- 5) *This Standard is subject to review within five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include “Proposal for change” in the subject line:*
 - a) *Standard designation (number);*