



UL 60947-4-1

STANDARD FOR SAFETY

Low-Voltage Switchgear and
Controlgear – Part 4-1: Contactors and
Motor-Starters – Electromechanical
Contactors and Motor-Starters

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

UL Standard for Safety for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, UL 60947-4-1

Fourth Edition, Dated May 31, 2022

Summary of Topics

Adoption of the Third Edition of IEC 60947-4-1, Standard for Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters, as the Fourth Edition of ANSI/UL 60947-4-1.

This standard is an adoption of IEC 60947-4-1, Edition 3.0, issued 2009 and its amendment 1, issued (2012). Please note that the National Difference document incorporates all of the U.S. national differences for UL 60947-4-1.

The requirements are substantially in accordance with Proposal(s) on this subject dated May 8, 2020 and September 10, 2021.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022



CSA Group
CSA C22.2 No. 60947-4-1:22
Third Edition
(IEC 60947-4-1:2009+A1:2012, MOD)



Underwriters Laboratories Inc.
UL 60947-4-1
Fourth Edition

Low-Voltage Switchgear and Controlgear – Part 4-1: Contactors and Motor-Starters – Electromechanical Contactors and Motor-Starters

May 31, 2022

This standard is based on IEC 60947-4-1, edition 3 (2009) consolidated with amendment 1 (2012).



ANSI/UL 60947-4-1-2022



Commitment for Amendments

This standard is issued jointly by the Canadian Standards Association (operating as "CSA Group") and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to CSA Group or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.

ISBN 978-1-4883-3147-3 © 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.

This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. The technical content of IEC and ISO publications is kept under constant review by IEC and ISO. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

To purchase CSA Group Standards and related publications, visit CSA Group's Online Store at www.csagroup.org/store/ or call toll-free 1-800-463-6727 or 416-747-4044.

Copyright © 2022 Underwriters Laboratories Inc.

UL's Standards for Safety are copyrighted by UL. Neither a printed nor electronic copy of a Standard should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

This ANSI/UL Standard for Safety consists of the Fourth Edition. The most recent designation of ANSI/UL 60947-4-1 as an American National Standard (ANSI) occurred on May 31, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

To purchase UL Standards, visit UL's Standards Sales Site at <http://www.shopulstandards.com/HowToOrder.aspx> or call toll-free 1-888-853-3503.

CONTENTS

PREFACE	7
NATIONAL DIFFERENCES	9
FOREWORD	11
INTRODUCTION(to amendment 1)	15
1 Scope and object	17
1.1 Scope	17
1.1DV.1 Modification of 1.1 by adding the following:	17
1.2 Exclusions	19
1.3 Object	19
2 Normative references	20
2DV Modification of Clause 2 by adding the following:	21
3 Terms, definitions, symbols and abbreviations	21
3.1 General	21
3.1DV Add the following definition to 3.1:	22
3.2 Alphabetical index of terms	22
3.3 Terms and definitions concerning contactors	24
3.4 Terms and definitions concerning starters	25
3.5 Terms and definitions concerning characteristic quantities	29
3.6 Symbols and abbreviations	30
4 Classification	31
5 Characteristics of contactors and starters	31
5.1 Summary of characteristics	31
5.2 Type of equipment	31
5.3 Rated and limiting values for main circuits	32
5.4 Utilization category	39
5.5 Control circuits	43
5.6 Auxiliary circuits	43
5.7 Characteristics of relays and releases (overload relays)	43
5.8 Co-ordination with short-circuit protective devices	46
5.9 Void	46
5.10 Types and characteristics of automatic change-over devices and automatic acceleration control devices	46
5.11 Types and characteristics of auto-transformers for two-step auto-transformer starters	47
5.12 Types and characteristics of starting resistors for rheostatic rotor starters	48
6 Product information	48
6.1 Nature of information	48
6.2 Marking	51
6.2DV Add Subclauses 6.2DV.1 to 6.2DV.4 and Table 6.2DV.1 to Clause 6.2 as follows:	51
6.3 Instructions for installation, operation and maintenance	55
7 Normal service, mounting and transport conditions	55
8 Constructional and performance requirements	55
8.1 Constructional requirements	55
8.2 Performance requirements	58
8.3 Electromagnetic compatibility (EMC)	76
8.3DV Modification of 8.3 and all subclauses by adding the following:	76
9 Tests	78
9.1 Kinds of test	78
9.2 Compliance with constructional requirements	80
9.2DV Modification of 9.2 by replacing 9.2.1 through 9.2.3 with the following:	81

9.3 Compliance with performance requirements	81
9.4 EMC Tests	111
9.4DV Modification of 9.4 and all subclauses by adding the following:	111

Annex A (normative) Marking and identification of terminals of contactors and associated overload relays

Annex ADV Modification to Annex A by replacing “normative” with “informative”:	124
A.1 General	124
A.2 Marking and identification of terminals of contactors	124
A.2.1 Marking and identification of terminals of coils	124
A.2.2 Marking and identification of terminals of main circuits	125
A.2.3 Marking and identification of terminals of auxiliary circuits	125
A.3 Marking and identification of terminals of overload relays	128

Annex B (normative) Special tests

Annex BDV Modification to Annex B by replacing “normative” with “informative”:	130
B.1 General	130
B.2 Mechanical durability	130
B.2.1 General	130
B.2.2 Verification of mechanical durability	130
B.3 Electrical durability	132
B.3.1 General	132
B.3.2 Results to be obtained	133
B.3.3 Statistical analysis of test results for contactors or starters	133
B.4 Co-ordination at the crossover current between the starter and associated SCPD	134
B.4.1 General and definitions	134
B.4.2 Condition for the test for the verification of co-ordination at the crossover current by a direct method	135
B.4.3 Test currents and test circuits	135
B.4.4 Test procedure and results to be obtained	135
B.4.5 Verification of co-ordination at the crossover current by an indirect method	136

Annex C Void

Annex D (informative) Items subject to agreement between manufacturer and user

Annex E (Void)

Annex F (normative) Requirements for auxiliary contact linked with power contact (mirror contact)

F.1 Scope and object	141
F.1.1 Scope	141
F.1.2 Object	141
F.2 Terms and definitions	141
F.3 Characteristics	141
F.4 Product information	141
F.5 Normal service, mounting and transport conditions	142
F.6 Constructional and performance requirements	142
F.7 Tests	142

F.7.1 General	142
F.7.2 Tests on products in a new condition	142
F.7.3 Test after conventional operational performance (defined under Table 10)	143

Annex G (informative) Rated operational currents and rated operational powers of switching devices for electrical motors

Annex GDV Modification to Annex G by replacing “informative” with “normative”	144
G.1 General	144
G.1DV Modification to G.1 by adding the following:	144
G.2 Rated operational powers and rated operational currents	144

Annex H (normative) Extended functions to electronic overload relays

H.1 General	148
H.2 Terms and definitions	148
H.3 Limits of operation of control functions	148
H.3.1 General	148
H.3.2 Limits of electronic overload relay with main circuit under-voltage restarting function	148
H.4 Test of the control functions	149

Annex I (informative) AC1 contactors for use with semiconductor controlled motor loads

Annex J Void

Annex K (normative) Procedure to determine data for electromechanical contactors used in functional safety applications

K.1 General	152
K.1.1 Introduction	152
K.1.2 Scope and object	152
K.1.3 General requirements	152
K.2 K.2 Terms, definitions and symbols	152
K.2.1 Terms and definitions	152
K.2.2 Symbols	153
K.3 Method based on durability test results	154
K.3.1 General method	154
K.3.2 Test requirements	154
K.3.3 Characterization of a failure mode	154
K.3.4 Weibull modelling	154
K.3.5 Useful life and upper limit of failure rate	156
K.3.6 Reliability data	157
K.4 Method based on experience of returns from the field	157
K.5 Data to be provided	158
K.6 Example	159
K.6.1 Test results	159
K.6.2 Weibull distribution and median rank regression	160
K.6.3 Useful life and failure rate	160

Annex DVA (normative) Reference standards

Annex DVA Add Annex DVA as follows:	162
---	-----

Annex DVB (normative) Standards for components

Annex DVB Add Annex DVB as follows: 164

Annex DVC (normative) Combination controllers, combination motor controllers and manual motor controllers

Annex DVC Add Annex DVC as follows: 167

Annex DVD (normative) Clearance and creepage distances for low voltage contactors and starters

Annex DVD Add Annex DVD as follows: 186

Bibliography

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

PREFACE

This is the harmonized CSA Group and UL standard for Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters. It is the third edition of CSA C22.2 No. 60947-4-1, and the fourth edition of UL 60947-4-1. This edition of CSA C22.2 No. 60947-4-1 supersedes the previous edition published in 2014 as CAN/CSA-C22.2 No. 60947-4-1.

This harmonized standard is based on IEC publication 60947-4-1, Edition 3.1, Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, issued July 2012. IEC 60947-4-1 is copyrighted by the IEC.

This harmonized standard was prepared by CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee for Industrial Control Equipment, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

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

This Standard was reviewed by the CSA Integrated Committee on Industrial Control, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA 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.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: 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.

CSA C22.2 No. 60947-4-1 is to be used in conjunction with the third edition of CSA C22.2 No. 60947-1. Requirements of this Standard, where stated, amend the requirements of CSA C22.2 No. 60947-1.

UL Standard 60947-4-1 is to be used in conjunction with the sixth edition of UL 60947-1. Requirements of this Standard, where stated, amend the requirements of UL 60947-1.

Level of Harmonization

This standard adopts the IEC text with national differences.

This standard is published as an equivalent standard for CSA Group and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

All national differences from the IEC text are included in the CSA Group and UL versions of the standard. While the technical content is the same in each organization's version, the format and presentation may differ.

Reasons for Differences From IEC

National differences from the IEC are being added in order to address safety and regulatory situations present in the US and Canada.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

IEC Copyright

For CSA Group, the text, figures, and tables of International Electrotechnical Commission Publication 60947-4-1, Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, copyright 2012, are used in this Standard with the consent of the International Electrotechnical Commission. The IEC Foreword and Introduction are not a part of the requirements of this Standard but are included for information purposes only.

These materials are subject to copyright claims of IEC and UL. No part of this publication may be reproduced in any form, including an electronic retrieval system, without the prior written permission of UL. All requests pertaining to the Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, UL 60947-4-1 Standard should be submitted to UL.

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

NATIONAL DIFFERENCES

National Differences from the text of International Electrotechnical Commission (IEC) Publication 60947-4-1, Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters, copyright 2012, are indicated by notations (differences) and are presented in bold text. The national difference type is included in the body.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters

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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This consolidated version of IEC 60947-4-1 consists of the third edition (2009) [documents 17B/1674/FDIS and 17B/1677/RVD] and its amendment 1 (2012) [documents 17B/1769/FDIS and 17B/1780/RVD]. It bears the edition number 3.1.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.

International Standard IEC 60947-4-1 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This edition includes the following significant technical changes with respect to the previous edition (2000) and its Amendments 1 (2002) and 2 (2005):

- deletion of the test at -5°C and $+20^{\circ}\text{C}$ for thermal overload relays that are not compensated for ambient air temperature;
- addition of conditions of the tests according to Annex Q of IEC 60947-1;
- EMC tests: clarification of acceptance criteria and alignment with IEC 60947-1 for fast transient severity level;
- Annex B, test for Icd: modification of the duration of the dielectric test voltage from 5 s to 60 s;
- Annex B, electrical durability: improvement of the statistical aspects;
- Annex H: clarification and introduction of new extended functions within electronic overload relays;
- Annex K, procedure to determine data for electromechanical contactors used in functional safety applications: creation of this new annex

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60947 series can be found, under the general title *Low voltage switchgear and controlgear*, on the IEC website.

This standard shall be read in conjunction with IEC 60947-1, *Low voltage switchgear and controlgear – Part 1: General rules*. The provisions of the general rules are applicable to this standard, where specifically called for.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

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

DV.1 DE Modification to replace the second paragraph following Item (9) of the IEC Foreword with the following:

This Final version does not show where the technical content is modified by amendment 1. A separate redline version with all changes highlighted is not available in this publication.

DV.2 DE Modification of the IEC Foreword by adding the following:

The numbering system in the standard uses a space instead of a comma to indicate thousands and uses a comma instead of a period to indicate a decimal point. For example, 1 000 means 1,000 and 1,01 means 1.01.

DV.3 D2 Modification of the IEC Foreword by adding the following:

This standard shall be read in conjunction with Canadian and United States equivalent standards to the IEC 60947 series per [Table DVA.2](#). Where specifically called for, any reference to IEC 60947-1 shall be to the applicable clause – either the national difference “DV” clause or IEC clause, or a reference to the applicable standard listed in the Annex. The provisions of the general rules are applicable to this standard, where specifically called for.

ULNORM.COM : Click to view the full PDF of UL 60947-4-1:2022

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

INTRODUCTION (to amendment 1)

This amendment includes the following significant technical changes with respect to the previous edition 3 (2009):

- introduction of the motor management starter;
- definitions and measurement method of the power consumption of the control circuit during holding and pick-up operations;
- measurement method of the pole impedance;
- requirements for screwless terminals;
- performance requirements for latched contactors;
- alignments to Amendment 1 of IEC 60947-1:2007;
- harmonisation with IEC 60947-2 of the operation tests of under-voltage relays and shunt releases;
- short-circuit tests harmonisation with North America;
- test requirements for utilisation AC-6b capacitor load;
- polarity for DC contactors;
- dielectric test method in presence of built-in varistor;
- addition of an extended function for electronic overload relay: control functions.

No Text on This Page

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR – Part 4-1:

Contactors and motor-starters – Electromechanical contactors and motor-starters

1 Scope and object

1.1 Scope

This part of IEC 60947 applies to the types of equipment listed in [1.1.1](#) and [1.1.2](#) whose main contacts are intended to be connected to circuits the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.

Starters and/or contactors dealt with in this standard are not normally designed to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see [9.3.4](#)) forms part of the installation but not necessarily of the contactor or the starter.

In this context, this standard gives requirements for:

- contactors associated with overload and/or short-circuit protective devices;
- starters associated with separate short-circuit protective devices and/or with separate short-circuit and integrated overload protective devices;
- contactors or starters combined, under specified conditions, with their own short-circuit protective devices. Such combinations, e.g. combination starters or protected starters are rated as units.

For circuit-breakers and fuse-combination units used as short-circuit protective devices in combination starters and in protected starters, the requirements of IEC 60947-2 and IEC 60947-3 respectively apply.

Equipment covered by this standard is as follows.

1.1DV.1 D2 Modification of 1.1 by adding the following:

This equipment is intended for installation in accordance with CSA C22.1, Canadian Electrical Code (CE Code, Part I), and the US National Electrical Code (NEC), NFPA 70.

1.1.1 AC and DC contactors

AC and DC contactors intended for closing and opening electric circuits and, if combined with suitable relays (see [1.1.2](#)), for protecting these circuits against operating overloads which may occur therein.

NOTE For contactors combined with suitable relays and which are intended to provide short-circuit protection, the relevant conditions specified for circuit-breakers (IEC 60947-2) additionally apply.

This standard applies also to the actuators of contactor relays and to the contacts dedicated exclusively to the coil circuit of a contactor.

Contactors or starters with an electronically controlled electromagnet are also covered by this standard.

1.1.1DV.1 D2 Modification of 1.1.1 by adding the following:

This standard also applies to manual controllers and combination motor controllers. See Annex [DVC](#) for specific requirements.

1.1.2 AC motor-starters

AC motor-starters (including motor management starter) intended to start and accelerate motors to normal speed, to ensure continuous operation of motors, to switch off the supply from the motor and to provide means for the protection of motors and associated circuits against operating overloads.

For overload relays for starters, including those based on electronic technology with or without extended functions according to Annex [H](#), the requirements of this standard apply.

1.1.2.1 Direct-on-line (full voltage) a.c. starters

Direct-on-line starters intended to start and accelerate a motor to normal speed, to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

This standard applies also to reversing starters.

1.1.2.2 Reduced voltage a.c. starters

Reduced voltage a.c. starters intended to start and accelerate a motor to normal speed by connecting the line voltage across the motor terminals in more than one step or by gradually increasing the voltage applied to the terminals, to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

Automatic change-over devices may be used to control the successive switching operations from one step to the others. Such automatic change-over devices are, for example, time-delay contactor relays or specified time all-or-nothing relays, under-current devices and automatic acceleration control devices (see [5.10](#)).

1.1.2.2.1 Star-delta starters

Star-delta starters intended to start a three-phase motor in the star connection, to ensure continuous operation in the delta connection, to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

The star-delta starters dealt with in this standard are not intended for reversing motors rapidly and, therefore, utilization category AC-4 does not apply.

NOTE In the star connection, the starting current in the line and the torque of the motor are about one-third of the corresponding values for delta connection. Therefore, star-delta starters are used when the inrush current due to the starting is to be limited, or when the driven machine requires a limited torque for starting. [Figure 1](#) indicates typical curves of starting current, of starting torque of the motor and of torque of the driven machine.

1.1.2.2.2 Two-step auto-transformer starters

Two-step auto-transformer starters, intended to start and accelerate an a.c. induction motor from rest with reduced torque to normal speed and to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

This standard applies to auto-transformers which are part of the starter or which constitute a unit specially designed to be associated with the starter.

Auto-transformer starters with more than two steps are not covered by this standard.

The auto-transformer starters dealt with in this standard are not intended for inching duty or reversing motors rapidly and, therefore, utilization category AC-4 does not apply.

NOTE In the starting position, the current in the line and the torque of the motor related to the motor starting with rated voltage are reduced approximately as the square of the ratio (starting voltage):(rated voltage). Therefore, auto-transformer starters are used when the inrush current due to the starting is to be limited or when the driven machine requires a limited torque for starting. [Figure 2](#) indicates typical curves of starting current, of starting torque of the motor and of torque of the driven machine.

1.1.2.3 Rheostatic rotor starters

Starters intended to start an a.c. induction motor having a wound rotor by cutting out resistors previously inserted in the rotor circuit, to provide means for the protection of the motor against operating overloads and to switch off the supply from the motor.

This standard applies also to starters for two directions of rotation when reversal of connections is made with the motor stopped (see [5.3.5.5](#)). Operations including inching and plugging necessitate additional requirements and are subject to agreement between manufacturer and user.

This standard applies to resistors which are part of the starter or constitute a unit specially designed to be associated with the starter.

1.2 Exclusions

This standard does not apply to:

- d.c. starters;
- star-delta starters, rheostatic rotor starters, two-step auto-transformer starters intended for special applications and designed for continuous operation in the starting position;
- unbalanced rheostatic rotor starters, i.e. where the resistances do not have the same value in all phases;
- equipment designed not only for starting, but also for adjustment of speed;
- liquid starters and those of the "liquid-vapour" type;
- semiconductor contactors and starters making use of semiconductor contactors in the main circuit;
- rheostatic stator starters;
- contactors or starters designed for special applications;
- auxiliary contacts of contactors and contacts of contactor relays. These are dealt with in IEC 60947-5-1.

1.3 Object

The object of this standard is to state:

a) the characteristics of contactors and starters and associated equipment;

b) the conditions applicable to contactors and starters with reference to:

- 1) their operation and behaviour,
- 2) their dielectric properties,
- 3) the degrees of protection provided by their enclosures, where applicable,
- 4) their construction;

c) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;

d) the information to be given with the equipment or in the manufacturer's literature.

2 Normative references

The following referenced documents are indispensable for the application 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.

IEC 60034-1:2004, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60300-3-5:2001, *Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-3:2008, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1 (2007)

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61051-2:1991, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*

IEC 61439-1:2009, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

IEC 61513:2001, *Nuclear power plants – Instrumentation and control for systems important to safety – General requirements for systems*

IEC 61649:2008, *Weibull analysis*

IEC 61810-1:2008, *Electromechanical elementary relays – Part 1: General requirements* (available in English only)

IEC 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

CISPR 11:2003, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

Amendment 1 (2004)

Amendment 2 (2006)

ISO 13849-1:2006, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

2DV D2 Modification of Clause 2 by adding the following:

For a list of normative standards, see [Table DVA.1](#) and [Table DVA.2](#). See [Table DVB.1](#) for component standards.

3 Terms, definitions, symbols and abbreviations

3.1 General

For the purposes of this document, the terms and definitions of Clause 2 of IEC 60947-1, as well as the following terms, definitions, symbol and abbreviations apply.

3.1DV D2 Add the following definition to 3.1:

3.1DV.1

Group installation

A motor branch circuit for two or more motors, or one or more motors with other loads and protected by a circuit breaker or a single set of fuses.

3.2 Alphabetical index of terms

		Reference
	A	
auto-transformer starter		3.4.5.2
	C	
closed transition (with an auto-transformer starter or star-delta starter)		3.4.23
combination starter		3.4.8
combination switching device		3.4.27
CO operation		3.5.2
contactor (mechanical)		3.3.1
	D	
direct-on-line starter		3.4.2
	E	
electromagnetic contactor		3.3.2
electromagnetic starter		3.4.10
electronically energized coil of electromagnet		3.3.8
electro-pneumatic contactor		3.3.4
electro-pneumatic starter		3.4.13
	H	
holding power		3.3.9
	I	
inching (jogging)		3.4.24
inhibit time		3.4.30
	J	
jam sensitive (electronic overload) relay		3.4.29
	L	
latched contactor		3.3.5
	M	
manual starter		3.4.9
mirror contact		F.2.1
motor management starter		3.4.31
motor-operated starter		3.4.11
	N	
<i>n</i> -step starter		3.4.16

	O	
O operation		3.5.3
open transition (with an auto-transformer starter or star-delta starter)		3.4.22
	P	
phase loss sensitive thermal overload relay or release		3.4.17
pick-up power		3.3.10
plugging		3.4.25
pneumatic contactor		3.3.3
pneumatic starter		3.4.12
position of rest (of a contactor)		3.3.7
protected starter		3.4.7
protected switching device		3.4.26
	R	
reduced voltage starter		3.4.5
reversing starter		3.4.3
rheostatic rotor starter		3.4.6.2
rheostatic starter		3.4.6
reostatic stator starter		3.4.6.1
	S	
single-step starter		3.4.14
stall sensitive (electronic overload) relay		3.4.28
star-delta starter		3.4.5.1
starter		3.4.1
starting time (of a rheostatic starter)		3.4.20
starting time (of an auto-transformer starter)		3.4.21
	T	
transient recovery voltage (abbreviation: TRV)		3.5.1
two-direction starter		3.4.4
two-step starter		3.4.15
	U	
under-current relay or release		3.4.18
under-voltage relay or release		3.4.19
	V	
vacuum contactor (or starter)		3.3.6

3.3 Terms and definitions concerning contactors

3.3.1

(mechanical) contactor

mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions

NOTE 1 Contactors may be designated according to the method by which the force for closing the main contacts is provided.

[IEV 441-14-33]

NOTE 2 The term "operated otherwise than by hand" means that the device is intended to be controlled and kept in working position from one or more external supplies.

NOTE 3 In French, a contactor the main contacts of which are closed in the position of rest is usually called a "rupteur". The word "rupteur" has no equivalent in the English language.

NOTE 4 A contactor is usually intended to operate frequently.

3.3.2

electromagnetic contactor

contactor in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by an electromagnet

NOTE The electromagnet may be electronically controlled.

3.3.3

pneumatic contactor

contactor in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by a device using compressed air, without the use of electrical means

3.3.4

electro-pneumatic contactor

contactor in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by a device using compressed air under the control of electrically operated valves

3.3.5

latched contactor

contactor, the moving elements of which are prevented by means of a latching arrangement from returning to the position of rest when the operating means are de-energized

NOTE 1 The latching, and the release of the latching, may be mechanical, electromagnetic, pneumatic, etc.

NOTE 2 Because of the latching, the latched contactor actually acquires a second position of rest and, according to the definition of a contactor, it is not, strictly speaking, a contactor. However, since the latched contactor in both its utilization and its design is more closely related to contactors in general than to any other classification of switching device, it is considered proper to require that it complies with the specifications for contactors wherever they are appropriate.

[IEV 441-14-34]

3.3.6

vacuum contactor (or starter)

contactor (or starter) in which the main contacts open and close within a highly evacuated envelope

3.3.7

position of rest (of a contactor)

position which the moving elements of the contactor take up when its electromagnet or its compressed-air device is not energized

[IEV 441-16-24]

3.3.8

electronically controlled electromagnet

electromagnet in which the coil is controlled by a circuit with active electronic elements

3.3.9

holding power (of a contactor)

power needed to maintain the operation of the electromagnet

3.3.10

pick-up power (of a contactor)

power needed to operate the contactor from the de-energized state to the energized state

3.4 Terms and definitions concerning starters

3.4.1

starter

combination of all the switching means necessary to start and stop a motor in combination with suitable overload protection

[IEV 441-14-38, modified]

3.4.2

direct-on-line starter

starter which connects the line voltage across the motor terminals in one step

[IEV 441-14-40]

3.4.3

reversing starter

starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections while the motor may be running

3.4.4

two-direction starter

starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections only when the motor is not running

3.4.5

reduced voltage starter

starter which connects the line voltage across the motor terminals in more than one step or by gradually increasing the voltage applied to the terminals

3.4.5.1

star-delta starter

starter for a three-phase induction motor such that in the starting position the stator windings are connected in star and in the final running position they are connected in delta

[IEV 441-14-44]

3.4.5.2

auto-transformer starter

starter for an induction motor which uses for starting one or more reduced voltages derived from an auto-transformer

[IEV 441-14-45]

NOTE An auto-transformer is defined as follows in 3.1.2 of IEC 60076-1: "A transformer in which at least two windings have a common part."

3.4.6

rheostatic starter

starter utilizing one or several resistors for obtaining, during starting, stated motor torque characteristics and for limiting the current

[IEV 441-14-42]

NOTE A rheostatic starter generally consists of three basic parts which may be supplied either as a composite unit or as separate units to be connected at the place of utilization:

- the mechanical switching devices for supplying the stator (generally associated with an overload protective device);
- the resistor(s) inserted in the stator or rotor circuit;
- the mechanical switching devices for cutting out the resistor(s) successively.

3.4.6.1

rheostatic stator starter

rheostatic starter for a squirrel cage motor which, during the starting period, cuts out successively one or several resistors previously provided in the stator circuit

3.4.6.2

rheostatic rotor starter

rheostatic starter for an asynchronous wound-rotor motor which, during the starting period, cuts out successively one or several resistors previously provided in the rotor circuit

[IEV 441-14-43]

3.4.7

protected starter

equipment consisting of a starter, a manually-operated switching device and a short-circuit protective device, rated as a unit by the manufacturer

NOTE 1 The protected starter may or may not be enclosed.

NOTE 2 In the context of this standard, the term "manufacturer" means any person, company or organization with ultimate responsibility as follows:

- to verify compliance with the appropriate standard;
- to provide the product information according to Clause 6.

NOTE 3 The manually operated switching device and the short-circuit protective device may be just one device and may also incorporate the starter overload protection.

3.4.8

combination starter (see [Figure 3](#))

equipment consisting of a protected starter incorporating an isolating function

NOTE Also called "combination motor controller".

3.4.9

manual starter

starter in which the force for closing the main contacts is provided exclusively by manual energy

[IEV 441-14-39]

3.4.10

electromagnetic starter

starter in which the force for closing the main contacts is provided by an electromagnet

3.4.11

motor-operated starter

starter in which the force for closing the main contacts is provided by an electric motor

3.4.12

pneumatic starter

starter in which the force for closing the main contacts is provided by using compressed air, without the use of electrical means

3.4.13

electro-pneumatic starter

starter in which the force for closing the main contacts is provided by using compressed air under the control of electrically operated valves

3.4.14

single-step starter

starter in which there is no intermediate accelerating position between the OFF and ON positions

NOTE This starter is a direct-on-line starter.

3.4.15

two-step starter

starter in which there is only one intermediate accelerating position between the OFF and ON positions

EXAMPLE A star-delta starter is a two-step starter.

3.4.16

***n*-step starter** (see [Figure 4](#))

starter in which there are (*n*-1) intermediate accelerating positions between the OFF and ON positions

[IEV 441-14-41]

EXAMPLE A three-step rheostatic starter has two sections of resistors used for starting.

3.4.17

phase loss sensitive thermal overload relay or release

multipole thermal overload relay or release which operates in the case of overload and also in case of loss of phase in accordance with specified requirements

3.4.18

under-current relay or release

measuring relay or release which operates automatically when the current through it is reduced below a predetermined value

3.4.19

under-voltage relay or release

measuring relay or release which operates automatically when the voltage applied to it is reduced below a predetermined value

3.4.20

starting time (of a rheostatic starter)

period of time during which the starting resistors or parts of them carry current

NOTE The starting time of a starter is shorter than the total starting time of the motor which also takes into account the last period of acceleration following the switching operation to the ON position.

3.4.21

starting time (of an auto-transformer starter)

period of time during which the auto-transformer carries current

NOTE The starting time of a starter is shorter than the total starting time of the motor which also takes into account the last period of acceleration following the switching operation to the ON position.

3.4.22

open transition (with an auto-transformer starter or star-delta starter)

circuit arrangement such that the supply to the motor is interrupted and reconnected when changing over from one step to another

NOTE The transition stage is not considered as an additional step.

3.4.23

closed transition (with an auto-transformer starter or star-delta starter)

circuit arrangement such that the supply to the motor is not interrupted (even momentarily) when changing over from one step to another

NOTE The transition stage is not considered as an additional step.

3.4.24

inching (jogging)

energizing a motor or solenoid repeatedly for short periods to obtain small movements of the driven mechanism

3.4.25

plugging

stopping or reversing a motor rapidly by reversing the motor primary connections while the motor is running

3.4.26

protected switching device

equipment (for non motor loads) consisting of a contactor or a semiconductor controller, overload protection, a manually operated switching device and a short-circuit protective device, rated as a unit by the manufacturer

NOTE 1 The protected switching device may or may not be enclosed.

NOTE 2 In the context of this standard, the term “manufacturer” means any person, company or organization with ultimate responsibility as follows:

- to verify compliance with the appropriate standard;
- to provide the product information according to Clause 6.

NOTE 3 The manually operated switching device and the short-circuit protective device may be just one device and may incorporate the overload protection as well.

3.4.27

combination switching device

equipment consisting of a protected switching device incorporating an isolating function

3.4.28

stall sensitive (electronic overload) relay

electronic overload relay which operates when the current has not decreased below a predetermined value for a specific period of time during start-up or when the relay receives the input indicating there is no rotation of the motor after a predetermined time in accordance with specified requirements

NOTE 1 Explanation of stall: rotor locked during start.

NOTE 2 With appropriate adjustment of the current and starting time settings, such relay can be used to detect overtime starts.

3.4.29

jam sensitive (electronic overload) relay

electronic overload relay which operates in the case of overload and also when the current has increased above a predetermined value for a specific period of time during operation, in accordance with specified requirements

NOTE Explanation of jam: high overload occurring after the completion of starting which causes the current to reach the locked rotor current value of the motor being controlled.

3.4.30

inhibit time

time-delay period during which the tripping function of the relay is inhibited (may be adjustable)

3.4.31

motor management starter

starter including extended functions with communication ability

NOTE Interoperable device profiles for motor management starter are defined by IEC 61915-2.

3.5 Terms and definitions concerning characteristic quantities

3.5.1

transient recovery voltage

TRV

recovery voltage during the time in which it has a significant transient character

NOTE In a vacuum contactor or starter, the highest transient recovery voltage may occur on an other pole than the first pole to clear.

[IEC 60947-1, 2.5.34, modified]

3.5.2

CO operation

breaking of the circuit by the SCPD resulting from closing the circuit by the equipment under test

3.5.3

O operation

breaking of the circuit by the SCPD resulting from closing the circuit on the equipment under test which is in the closed position

NOTE The SCPD is normally in the closed position prior closing the circuit; in some cases the SCPD has to close the circuit [9.3.4.2.2](#), item b).

3.6 Symbols and abbreviations

AQL	Acceptable quality level
EMC	Electromagnetic compatibility
SCPD	Short-circuit protective device
I_c	Current made and broken (Table 7)
I_e	Rated operational current (5.3.2.5)
I_{er}	Rated rotor operational current (5.3.2.7)
I_{es}	Rated stator operational current (5.3.2.6)
I_q	Maximum conditional short-circuit test current
I_{th}	Conventional free air thermal current (5.3.2.1)
I_{the}	Conventional enclosed thermal current (5.3.2.2)
I_{thr}	Conventional rotor thermal current (5.3.2.4)
I_{ths}	Conventional stator thermal current (5.3.2.3)
I_u	Rated uninterrupted current (5.3.2.8)
P_c	Nominal holding power of a d.c. controlled contactor
P_p	Pick-up power of a d.c. controlled contactor with separate pick-up and hold-on windings
" I "	Minimum short-circuit test current
S_h	Holding power of an a.c. controlled contactor
S_p	Pick-up power of an a.c. controlled contactor
T_p	Tripping time (Table 2)
U_c	Rated control circuit voltage (5.5)
U_d	Voltage drop of a contactor pole
U_e	Rated operational voltage (5.3.1.1)
U_{er}	Rated rotor operational voltage (5.3.1.1.2)
U_{es}	Rated stator operational voltage (5.3.1.1.1)
U_i	Rated insulation voltage (5.3.1.2)
U_{imp}	Rated impulse withstand voltage (5.3.1.3)
U_{ir}	Rated rotor insulation voltage (5.3.1.2.2)
U_{is}	Rated stator insulation voltage (5.3.1.2.1)

U_r	Power frequency or d.c. recovery voltage (Table 7)
U_s	Rated control supply voltage (5.5)
Z	Pole impedance of a contactor (5.3.7)

4 Classification

Subclause [5.2](#) gives all the data which may be used as criteria for classification.

5 Characteristics of contactors and starters

5.1 Summary of characteristics

The characteristics of a contactor or starter shall be stated in the following terms, where such terms are applicable:

- type of equipment ([5.2](#));
- rated and limiting values for main circuits ([5.3](#));
- utilization category ([5.4](#));
- control circuits ([5.5](#));
- auxiliary circuits ([5.6](#));
- types and characteristics of relays and releases ([5.7](#));
- co-ordination with short-circuit protective devices ([5.8](#));
- types and characteristics of automatic change-over devices and automatic acceleration control devices ([5.10](#));
- types and characteristics of auto-transformers for two-step auto-transformer starters ([5.11](#));
- types and characteristics of starting resistors for rheostatic rotor starters ([5.12](#)).

5.2 Type of equipment

The following shall be stated (see also Clause [6](#)).

5.2.1 Kind of equipment

- contactor;
- direct-on-line a.c. starter;
- star-delta starter;
- two-step auto-transformer starter;

- rheostatic rotor starter;
- combination or protected starter.

5.2.2 Number of poles

5.2.3 Kind of current (a.c. or d.c.)

5.2.4 Interrupting medium (air, oil, gas, vacuum, etc.)

5.2.5 Operating conditions of the equipment

5.2.5.1 Method of operation

For example: manual, electromagnetic, motor-operated, pneumatic, electro-pneumatic.

5.2.5.2 Method of control

For example:

- automatic (by pilot switch or sequence control);
- non-automatic (such as by hand operation or by push-buttons);
- semi-automatic (i.e. partly automatic, partly non-automatic).

5.2.5.3 Method of change-over for particular types of starters

The change-over for star-delta starters, rheostatic rotor starters or auto-transformer starters may be automatic, non-automatic or semi-automatic (see [Figure 4](#) and [Figure 5](#)).

5.2.5.4 Method of connecting for particular types of starters

For example: open transition starter, closed transition starter (see [Figure 5](#)).

5.3 Rated and limiting values for main circuits

The rated values established for a contactor or starter shall be stated in accordance with [5.3.1](#) to [5.4](#), and [5.8](#) and [5.9](#), but it may not be necessary to specify all the values listed.

NOTE The rated values established for a rheostatic rotor starter are stated in accordance with [5.3.1.2](#), [5.3.2.3](#), [5.3.2.4](#), [5.3.2.6](#), [5.3.2.7](#) and [5.3.5.5](#) but it is not necessary to specify all the values listed.

5.3.1 Rated voltages

A contactor or starter is defined by the following rated voltages.

5.3.1.1 Rated operational voltage (U_e)

Subclause 4.3.1.1 of IEC 60947-1 applies.

5.3.1.1.1 Rated stator operational voltage (U_{es})

For rheostatic rotor starters, a rated stator operational voltage is a value of voltage which, when combined with a rated stator operational current, determines the application of the stator circuit including its mechanical switching devices and to which are referred the making and breaking capacities, the type of duty and the starting characteristics. In no case shall the maximum rated operational voltage exceed the corresponding rated insulation voltage.

NOTE The rated stator operational voltage is expressed as the voltage between phases.

5.3.1.1.2 Rated rotor operational voltage (U_{er})

For rheostatic rotor starters, the value of rated rotor operational voltage is that of the voltage which, when combined with a rated rotor operational current, determines the application of the rotor circuit including its mechanical switching devices and to which are referred the making and breaking capacities, the type of duty and the starting characteristics.

This voltage is taken as equal to the voltage measured between slip-rings, with the motor stopped and the rotor open-circuited, when the stator is supplied at its rated voltage.

The rated insulation voltage of the switching devices inserted in the rotor circuit shall be at least 50 % the highest voltage between open slip-rings.

NOTE Electrical stresses are lower and shorter in the rotor than in the stator.

The rated rotor operational voltage is only applied for a short duration during the starting period. For this reason, it is permissible that the rated rotor operational voltage exceed the rated rotor insulation voltage by 100 %.

The maximum voltage between the different live parts (e.g. switching devices, resistors, connecting parts, etc.) of the rotor circuit of the starter will vary and account may be taken of this fact in choosing the equipment and its disposition.

5.3.1.2 Rated insulation voltage (U_i)

Subclause 4.3.1.2 of IEC 60947-1 applies.

5.3.1.2.1 Rated stator insulation voltage (U_{is})

For rheostatic rotor starters, the rated stator insulation voltage is the value of voltage which is designated for the devices inserted in the stator supply, as well as the unit they are part of, and to which dielectric tests and creepage distances are referred.

Unless otherwise stated, the rated stator insulation voltage is the value of the maximum rated stator operational voltage of the starter.

5.3.1.2.2 Rated rotor insulation voltage (U_{ir})

For rheostatic rotor starters, the rated rotor insulation voltage is the value of voltage which is designated to the devices inserted in the rotor circuit, as well as the unit they are part of (connecting links, resistors, enclosure), and to which dielectric tests and creepage distances are referred.

5.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of IEC 60947-1 applies.

5.3.1.4 Rated starting voltage of an auto-transformer starter

The rated starting voltage of an auto-transformer starter is the reduced voltage derived from the transformer.

Preferred values of rated starting voltage are 50 %, 65 % or 80 % of the rated operational voltage.

5.3.2 Currents or powers

A contactor or a starter is defined by the following currents.

NOTE In the case of a star-delta starter, these currents relate to the delta connection and, in the case of a two-step auto-transformer or rheostatic rotor starter, to the ON position.

5.3.2.1 Conventional free air thermal current (I_{th})

Subclause 4.3.2.1 of IEC 60947-1 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of IEC 60947-1 applies.

5.3.2.3 Conventional stator thermal current (I_{ths})

The conventional stator thermal current of a starter may be either free air current I_{ths} or enclosed current I_{thes} , in line with [5.3.2.1](#) and [5.3.2.2](#).

For a rheostatic rotor starter, the stator thermal current is the maximum current it can carry on eight-hour duty (see [5.3.4.1](#)) without the temperature rise of its several parts exceeding the limits specified in [8.2.2](#) when tested in accordance with [9.3.3.3](#).

5.3.2.4 Conventional rotor thermal current (I_{thr})

The conventional rotor thermal current of a starter may be either free air current I_{thr} or enclosed current I_{ther} , in line with [5.3.2.1](#) and [5.3.2.2](#).

For rheostatic rotor starters, the rotor thermal current is the maximum current that those parts of the starter through which the rotor current flows in the ON position, precisely after cutting out resistors, can carry on eight-hour duty (see [5.3.4.1](#)) without their temperature rise exceeding the limits specified in [8.2.2](#) when tested in accordance with [9.3.3.3](#).

NOTE 1 For those elements (switching devices, connecting links, resistors) through which a current of practically no value flows in the ON position, it should be verified that, for the rated duties (see [5.3.4](#)) stated by the manufacturer, the value of integral

$$\int_0^t i^2 dt$$

does not lead to temperature rises higher than those appearing in [8.2.2](#).

NOTE 2 When resistors are built-in into the starter, the temperature rise should be taken into account.

5.3.2.5 Rated operational currents (I_e) or rated operational powers

A rated operational current of a contactor or a starter is stated by the manufacturer and takes into account the rated operational voltage (see 5.3.1.1), the conventional free air or enclosed thermal current, the rated current of the overload relay, the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the utilization category (see 5.4) and the type of protective enclosure, if any.

In the case of equipment for direct switching of individual motors, the indication of a rated operational current may be replaced or supplemented by an indication of the maximum rated power output, at the rated operational voltage considered, of the motor for which the equipment is intended. The manufacturer shall be prepared to state the relationship assumed between the current and the power.

NOTE Annex G gives values concerning the relationship between rated operational currents and rated operational powers.

For starters, the rated operational current (I_e) is the current in the ON position of the starter.

5.3.2.6 Rated stator operational current (I_{es}) or rated stator operational power

For rheostatic rotor starters, a rated stator operational current is stated by the manufacturer and takes into account the rated current of the overload relay installed in this starter, the rated stator operational voltage (see 5.3.1.1.1), the conventional free air or enclosed thermal current, the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the starting characteristics (see 5.3.5.5) and the type of protective enclosure.

The indication of a rated stator operational current may be replaced by the indication of the maximum rated power output, at the rated stator operational voltage considered, of the motor for which the stator elements of the starter are intended. The manufacturer shall be prepared to state the relationship assumed between the motor power and the stator current.

5.3.2.7 Rated rotor operational current (I_{er})

For rheostatic rotor starters, a rated rotor operational current is stated by the manufacturer and takes into account the rated rotor operational voltage (see 5.3.1.1.2), the conventional free air or enclosed rotor thermal current, the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the starting characteristics (see 5.3.5.5) and the type of protective enclosure.

It is taken as equal to the current flowing in the connections to the rotor when the latter is short-circuited and the motor is running at full load and the stator is supplied at its rated voltage and rated frequency.

When the rotor part of a rheostatic rotor starter is rated separately, the indication of a rated rotor operational current may be supplemented by the maximum rated power output, for motors having the rated rotor operational voltage considered, of the motor for which that part of the starter (switching devices, connecting links, relays, resistors) is intended. This power varies in particular with the breakaway torque foreseen and consequently takes into account the starting characteristics (see 5.3.5.5).

5.3.2.8 Rated uninterrupted current (I_u)

Subclause 4.3.2.4 of IEC 60947-1 applies.

5.3.3 Rated frequency

Subclause 4.3.3 of IEC 60947-1 applies.

5.3.4 Rated duties

Subclause 4.3.4 of IEC 60947-1 applies.

5.3.4.1 Eight-hour duty (continuous duty)

Subclause 4.3.4.1 of IEC 60947-1 applies with the following addition.

For a star-delta starter, a two-step auto-transformer starter or a rheostatic rotor-starter, the continuous duty is the duty in which the starter is in the ON position and the main contacts of the switching devices which constitute it, which are closed in this position, remain closed while each of them carries a steady current long enough for the starter to reach thermal equilibrium, but not for more than 8 h without interruption.

5.3.4.2 Uninterrupted duty

Subclause 4.3.4.2 of IEC 60947-1 applies with the following addition.

For a star-delta starter, a two-step auto-transformer starter or a rheostatic rotor starter, the uninterrupted duty is the duty in which the starter is in the ON position and the main contacts of the switching devices which constitute it, which are closed in this position, remain closed without interruption while each of them carries a steady current for periods of more than 8 h (weeks, months or even years).

5.3.4.3 Intermittent periodic duty or intermittent duty

Subclause 4.3.4.3 of IEC 60947-1 applies with the following addition.

For a reduced voltage starter, the intermittent duty is the duty in which the starter is in the ON position and the main contacts of the switching devices which constitute it remain closed for periods bearing a definite relation to the no-load periods, both periods being too short to allow the starter to reach thermal equilibrium.

Preferred classes of intermittent duty are:

- for contactors: 1, 3, 12, 30, 120, 300 and 1 200 (operating cycles per hour);
- for starters: 1, 3, 12 and 30 (operating cycles per hour).

It is recalled that an operating cycle is a complete working cycle comprising one closing operation and one opening operation.

For starters, an operating cycle comprises starting, running to full speed and switching off the supply from the motor.

NOTE In the case of starters for intermittent duty, the difference between the thermal time-constant of the overload relay and that of the motor may render a thermal relay unsuited for overload protection. It is recommended that, for installations intended for intermittent duty, the question of overload protection be subject to agreement between manufacturer and user.

5.3.4.4 Temporary duty

Subclause 4.3.4.4 of IEC 60947-1 applies.

5.3.4.5 Periodic duty

Subclause 4.3.4.5 of IEC 60947-1 applies.

5.3.5 Normal load and overload characteristics

Subclause 4.3.5 of IEC 60947-1 applies with the following additions.

5.3.5.1 Ability to withstand motor switching overload currents

Requirements to meet these conditions are given for contactors in [8.2.4.4](#).

5.3.5.2 Rated making capacity

Requirements for the various utilization categories (see [5.4](#)) are given in [8.2.4.1](#). The rated making and breaking capacities are only valid when the contactor or the starter is operated in accordance with the requirements of [8.2.1.1](#) and [8.2.1.2](#).

5.3.5.3 Rated breaking capacity

Requirements for the various utilization categories (see [5.4](#)) are given in [8.2.4.1](#). The rated making and breaking capacities are only valid when the contactor or the starter is operated in accordance with the requirements of [8.2.1.1](#) and [8.2.1.2](#).

5.3.5.4 Conventional operational performance

This performance is specified as a series of making and breaking operations in [8.2.4.2](#).

5.3.5.5 Starting and stopping characteristics of starters (see [Figure 6](#))

Typical service conditions for starters are:

- a) one direction of rotation with the motor being switched off during running in normal service conditions (utilization categories AC-2 and AC-3);
- b) two directions of rotation, but the running in the second direction is realized after the starter has been switched off and the motor has completely stopped (utilization categories AC-2 and AC-3);
- c) one direction of rotation, or two directions of rotation as in item b), but with the possibility of infrequent inching (jogging). For this service condition, direct-on-line starters are usually employed (utilization category AC-3);
- d) one direction of rotation with frequent inching (jogging). Usually direct-on-line starters (utilization category AC-4) are used for this duty;
- e) one or two directions of rotation, but with the possibility of infrequent plugging for stopping the motor, plugging being associated, if so provided, with rotor resistor braking (reversing starter with braking). Usually a rheostatic rotor starter is used for this duty condition (utilization category AC-2);
- f) two directions of rotation, but with the possibility of reversing the supply connections to the motor while it is running in the first direction (plugging), in order to obtain its rotation in the other direction, with switching off the motor running in normal service conditions. Usually a direct-on-line reversing starter is used for this duty condition (utilization category AC-4).

Unless otherwise stated, starters are designed on the basis of the starting characteristics of the motors compatible with the making capacities of [Table 7](#). These making capacities cover both the transient and steady-state starting currents of the great majority of standard motors. However, the starting currents for some large motors may attain peak values corresponding to power factors considerably lower than those specified for the test circuit in [Table 7](#). In these cases, the operational current of the contactor or starter should be decreased to a value lower than its rated value such that the making capacity of the contactor or starter is not exceeded.

5.3.5.5.1 Starting characteristics of rheostatic rotor starters

A distinction shall be drawn between the currents and voltages in the stator and rotor circuits of slip-ring motors. However, the changes of the current values in stator and rotor circuits, caused by the various steps of the starting process, are nearly proportional under normal operating conditions.

The following definitions deal mainly with the characteristics of the rotor circuit:

U_{er} is the rated rotor operational voltage;

I_{er} is the rated rotor operational current;

Z_r is the characteristic impedance of the rotor of an a.c. slip-ring induction motor;

where

$$Z_r = \frac{U_{er}}{\sqrt{3} \times I_{er}}$$

I_1 is the current in the rotor circuit immediately before shorting out a resistor section;

I_2 is the current in the rotor circuit immediately after shorting out a resistor section;

$I_m = 1/2 (I_1 + I_2)$;

T_e is the rated motor operational torque;

t_s is the starting time;

k is the severity of start = I_m / I_{er}

It is recognized that many rheostatic rotor starter applications have very specific starting requirements which may result not only in a different number of starting steps and different values of I_1 and I_2 , but also in the values of I_1 and I_2 being different for individual resistor sections. Therefore, no attempt has been made to lay down standard parameters, but the following factors should be taken into consideration:

- for most applications, between two and six starting steps are adequate depending upon load torque, inertia and the severity of start required;
- the resistor sections should be designed to have adequate thermal ratings bearing in mind the starting time of the drive, which will be dependent upon load torque and load inertia.

5.3.5.5.2 Standard conditions for making and breaking corresponding to the starting characteristics for rheostatic rotor starters

These conditions are given in [Table 7](#) and apply to starting with high torque. (For the designation of the mechanical switching devices, see [Figure 4](#).)

The conditions for making and breaking as given in [Table 7](#) for AC-2 utilization category are considered as standard.

The starter circuit shall be designed to open all rotor resistor switching devices before or approximately simultaneously with the opening of the stator switching device. Otherwise, the stator switching device shall comply with AC-3 requirements.

5.3.5.5.3 Starting characteristics for two-step auto-transformer starters

Unless otherwise stated, the auto-transformer starters and specifically the auto-transformers are designed on the condition that the starting time for all classes of duty (see [5.3.4](#)) shall not exceed 15 s. The number of starting cycles per hour assumes equal periods between starts except that, in the event of two operating cycles being made in rapid succession, the starter and the auto-transformer shall be allowed to cool to ambient air temperature before a further start is made.

When a starting time in excess of 15 s is required, this shall be the subject of agreement between manufacturer and user.

5.3.6 Rated conditional short-circuit current

Subclause 4.3.6.4 of IEC 60947-1 applies.

5.3.7 Pole impedance of a contactor (Z)

The pole impedance may be stated by the manufacturer and is determined by measuring the voltage drop resulting of the current flowing through the pole.

5.4 Utilization category

5.4.1 General

Subclause 4.4 of IEC 60947-1 applies with the following additions.

For contactors and starters, the utilization categories as given in [Table 1](#) are considered standard. Any other type of utilization shall be based on agreement between manufacturer and user, but information given in the manufacturer's catalogue or tender may constitute such an agreement.

Each utilization category is characterized by the values of the currents, voltages, power-factors or time-constants and other data of [Table 7](#) and [Table 10](#), and by the test conditions specified in this standard.

For contactors or starters defined by their utilization category, it is therefore unnecessary to specify separately the rated making and breaking capacities as these values depend directly on the utilization category as shown in [Table 7](#).

The voltage for all utilization categories is the rated operational voltage of a contactor or a starter other than a rheostatic rotor starter, and the rated stator operational voltage for a rheostatic rotor starter.

All direct-on-line starters belong to one or more of the following utilization categories: AC-3, AC-4, AC-7b, AC-8a and AC-8b. All star-delta and two-step auto-transformer starters belong to utilization category AC-3.

Rheostatic rotor starters belong to utilization category AC-2.

5.4.1DV D2 Modification of 5.4.1 by adding the following:

The equipment rating and required load designation shall be in accordance with [Table 5.4.1DV](#), and are characterized by the values of the currents, voltages, power-factors or time-constants and other data of [Table 8.2.4.1DV.1.1](#) and [Table 8.2.4.2DV.1.1](#), and by the test conditions specified in this standard.

Table 5.4.1DV
Ratings of a device controlling an external load

Load type	Equivalent ¹ utilization category	Equipment rating	Required load marking	Additional load ¹ designations
General purpose; Non-inductive or slightly inductive	AC-1	Amperes	None or General use	AC-1
General purpose; Non-inductive or slightly inductive	DC-1	Amperes	None or General use	DC-1
AC Resistance (not air heating)	—	Amperes	Resistive or Res	None
DC Resistance (not air heating)	—	Amperes	Resistive or Res	None
AC Electric Heating Control ²	—	Amperes	None	None
Resistance air heating, AC	—	Amperes	Resistance or Resistance air heating	None
Resistance air heating, DC	—	Amperes	Resistance or Resistance air heating	None
Incandescent lamp, AC	AC-5b	Amperes or watts	Tungsten	AC-5b
Incandescent lamp, DC	DC-6	Amperes or watts	Tungsten	DC-6
Ballast (electric discharge lamp)	AC-5a	Amperes	Ballast	AC-5a
Motor controller (Hermetic Compressor Rating)	AC-8a	FLA and LRA	"Hermetic Refrigeration Compressor" or "herm. refrig. comp."	AC-8a
Motor controller (Hermetic Compressor, Recycle Rating)	AC-8b	LRA	None	AC-8b
Motor controller (Hermetic Compressor, Part-	—	FLA and LRA	None	None

Table 5.4.1DV Continued on Next Page

Table 5.4.1DV Continued

Load type	Equivalent ¹ utilization category	Equipment rating	Required load marking	Additional load ¹ designations
Winding Endurance (Rating)				
Motor (non- standard rating)	–	FLA and LRA	None	None
Motor controller (standard rating)	–	Horsepower	None	None
Motor controller (Starting, plugging, inching)	AC-4	Horsepower	AC-4	None
Manual motor controller suitable for motor disconnecting means	–	Horsepower or FLA and LRA	"Suitable as Motor Disconnect"	None
Motor controller for elevator control	–	Horsepower or FLA and LRA	Elevator duty	None
Motor and tap conductor protection	–	Horsepower or FLA and LRA	"Suitable for Tap Conductor Protection in Group Installations"	None
Capacitive switching	AC-6b	kVar and FLA	None	None
(1) When the marked ratings are the utilization category code designations in the table, the information concerning the load characteristics for each code designation shall be published in a catalog, be contained on a marking sheet packed with the product, or be otherwise readily available to the user.				
(2) Electric Heating Control rating applies in Canada only.				

5.4.2 Assignment of utilization categories based on the results of tests

a) A contactor or starter which has been tested for one utilization category or at any combination of parameters (such as highest operational voltage and current, etc.) can be assigned other utilization categories without testing, provided that the test currents, voltages, power-factors or time-constants, number of operating cycles, on and off times given in [Table 7](#) and [Table 10](#), and the test circuit for the assigned utilization categories are not more severe than those at which the contactor or starter has been tested and the temperature rise has been verified at a current not less than the highest assigned rated operational current in continuous duty.

For example, when tested for utilization category AC-4, a contactor may be assigned utilization category AC-3 provided I_e for AC-3 is not higher than $1,2 I_e$ for AC-4 at the same rated operational voltage.

b) DC-3 and DC-5 contactors are assumed to be capable of opening and closing loads other than those on which they have been tested provided that:

- the voltage and current do not exceed the specified values of U_e and I_e ;
- the energy J stored in the actual load is equal to or less than the energy J_c stored in the load with which they were tested.

The values of the energy stored in the test circuit are as follows:

Utilization category	Stored energy J_c
DC-3	$0,005\ 25 \times U_e \times I_e$
DC-5	$0,031\ 5 \times U_e \times I_e$

The values of the constants 0,005 25 and 0,031 5 are derived from:

$$J_c = 1 / 2 L I^2$$

where the time-constant has been replaced by:

$2,5 \times 10^{-3}$ s (DC-3) and:

15×10^{-3} s (DC-5)

and where $U = 1,05 U_e$, $I = 4 I_e$ and L is the inductance of the test circuit.

(See [Table 7](#) of this standard.)

Table 1
Utilization categories

Kind of current	Utilization categories	Additional category designation	Typical applications
AC	AC-1	General use	Non-inductive or slightly inductive loads, resistance furnaces
	AC-2		Slip-ring motors: starting, switching off
	AC-3		Squirrel-cage motors: starting, switching off motors during running ^a
	AC-4		Squirrel-cage motors: starting, plugging, inching
	AC-5a	Ballast	Switching of electric discharge lamp controls
	AC-5b	Incandescent	Switching of incandescent lamps
	AC-6a		Switching of transformers
	AC-6b		Switching of capacitor banks
	AC-7a ^c		Slightly inductive loads in household appliances and similar applications
	AC-7b ^c		Motor-loads for household applications
	AC-8a		Hermetic refrigerant compressor motor ^b control with manual resetting of overload releases
	AC-8b		Hermetic refrigerant compressor motor ^b control with automatic resetting of overload releases
DC	DC-1		Non-inductive or slightly inductive loads, resistance furnaces
	DC-3		Shunt-motors: starting, plugging, inching
			Dynamic breaking of d.c. motors
	DC-5		Series-motors: starting, plugging, inching
			Dynamic breaking of d.c. motors
	DC-6	Incandescent	Switching of incandescent lamps

Table 1 Continued on Next Page

Table 1 Continued

Kind of current	Utilization categories	Additional category designation	Typical applications
^a AC-3 category may be used for occasional inching (jogging) or plugging for limited time periods such as machine set-up; during such limited time periods, the number of such operations should not exceed five per minute or more than ten in a 10-min period.			
^b A hermetic refrigerant compressor motor is a combination consisting of a compressor and a motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, the motor operating in the refrigerant.			
^c For AC-7a and AC-7b, see IEC 61095.			

5.5 Control circuits

Subclause 4.5 of IEC 60947-1:2007 applies.

5.6 Auxiliary circuits

Subclause 4.6 of IEC 60947-1 applies.

Digital inputs and/or digital outputs contained in contactors and motor-starters, and intended to be compatible with PLCs shall fulfil the requirements of Annex S of IEC 60947-1.

5.7 Characteristics of relays and releases (overload relays)

NOTE In the remainder of this standard, the words "overload relay" will be taken to apply equally to an overload relay or an overload release, as appropriate.

5.7.1 Summary of characteristics

The characteristics of relays and releases shall be stated in the following terms, whenever applicable:

- types of relay or release (see 5.7.2);
- characteristic values (see 5.7.3);
- designation and current settings of overload relays (see 5.7.4);
- time-current characteristics of overload relays (see 5.7.5);
- influence of ambient air temperature (see 5.7.6).

5.7.2 Types of relay or release

- a) Release with shunt coil (shunt trip).
- b) Under-voltage and under-current opening relay or release.
- c) Overload time-delay relay the time-lag of which is:
 - 1) substantially independent of previous load;
 - 2) dependent on previous load;
 - 3) dependent on previous load and also sensitive to phase loss.

d) Instantaneous over-current relay or release (e.g. jam sensitive).

e) Other relays or releases (e.g. control relay associated with devices for the thermal protection of the motor).

f) Stall relay or release.

5.7.3 Characteristic values

a) Release with shunt coil, under-voltage (under-current), over-voltage (instantaneous over current), current or voltage imbalance and phase reversal opening relay or release:

- rated voltage (current);
- rated frequency;
- operating voltage (current);
- operating time (when applicable);
- inhibit time (when applicable).

b) Overload relay:

- designation and current settings (see [5.7.4](#));
- rated frequency, when necessary (for example in the case of a current transformer operated overload relay);
- time-current characteristics (or range of characteristics), when necessary;
- trip class according to classification in [Table 2](#), or the value of the maximum tripping time, in seconds, under the conditions specified in [8.2.1.5.1](#), [Table 3](#), column D, when this time exceeds 40 s;
- nature of the relay: thermal, magnetic, electronic or electronic without thermal memory (electronic relay not fulfilling the thermal memory test verification according [8.2.1.5.1.2](#) shall be marked ~~Thm~~);
- nature of the reset: manual and/or automatic; in case of combination manual or automatic-reset, the set position shall be indicated;
- tripping time of overload relays class 10A if longer than 2 min at –5 °C or below (see [8.2.1.5.1.1](#), item c).

c) Release with residual current sensing relay:

- rated current;
- operating current;
- operating time or time-current characteristic according to Table T.1 of IEC 60947-1:2007, Amendment 1;
- inhibit time (when applicable);

– type designation (see Annex T of IEC 60947-1: 2007, Amendment 1).

5.7.3DV D2 Modification of 5.7.3 by replacing the fifth dashed item of Item (b) with the following:

– Installation instructions for overload relays without thermal memory shall indicate that thermal memory is not provided. Marking of the symbol ~~Thm~~ is optional.

Table 2
Trip classes of overload relays

Trip class	Tripping time T_p under the conditions specified in 8.2.1.5.1 , Table 3 , column D ^a	Tripping time T_p under the conditions specified in 8.2.1.5.1 , Table 3 , column D for tighter tolerances (tolerance band E) ^a
	s	s
2	–	$T_p \leq 2$
3	–	$2 < T_p \leq 3$
5	$0,5 < T_p \leq 5$	$3 < T_p \leq 5$
10 A	$2 < T_p \leq 10$	–
10	$4 < T_p \leq 10$	$5 < T_p \leq 10$
20	$6 < T_p \leq 20$	$10 < T_p \leq 20$
30	$9 < T_p \leq 30$	$20 < T_p \leq 30$
40	–	$30 < T_p \leq 40$

^a The manufacturer shall add the letter E to trip classes to indicate compliance with the band E.

NOTE 1 Depending on the nature of the relay, the tripping conditions are given in [8.2.1.5](#).

NOTE 2 In the case of a rheostatic rotor starter, the overload relay is commonly inserted in the stator circuit. As a result, it cannot efficiently protect the rotor circuit and more particularly the resistors (generally more easily damageable than the rotor itself or the switching devices in case of a faulty start); protection of the rotor circuit should be the subject of a specific agreement between manufacturer and user (see, inter alia, [8.2.1.1.3](#)).

NOTE 3 In the case of a two-step auto-transformer starter, the starting auto-transformer is normally designed for use during the starting period only; as a result, it cannot be efficiently protected by the overload relay in the event of faulty starting. Protection of the auto-transformer should be the subject of specific agreement between manufacturer and user (see [8.2.1.1.4](#)).

NOTE 4 The lower limiting values of T_p are selected to allow for differing heater characteristics and manufacturing tolerances.

Table 2DV D2 Modification of Table 2 by replacing NOTE 4 with the following:

NOTE 4 Testing at the lower limiting values is optional.

5.7.4 Designation and current settings of overload relays

Overload relays are designated by their current setting (or the upper and lower limits of the current setting range, if adjustable) and their trip class.

The current setting (or current setting range) shall be marked on the relays.

However, if the current setting is influenced by the conditions of use or other factors which cannot readily be marked on the relay, then the relay or any interchangeable parts thereof (e.g. heaters, operating coils or current transformers) shall carry a number or an identifying mark which makes it possible to obtain the

relevant information from the manufacturer or his catalogue or, preferably, from data furnished with the starter.

In the case of current transformer operated overload relays, the marking may refer either to the primary current of the current transformer through which they are supplied or to the current setting of the overload relays. In either case, the ratio of the current transformer shall be stated.

5.7.5 Time-current characteristics of overload relays

Typical time-current characteristics shall be given in the form of curves supplied by the manufacturer. These curves shall indicate how the tripping time, starting from the cold state (see 5.7.6), varies with the current up to a value of at least eight times the full-load current of the motor with which it is intended that the relay be used. The manufacturer shall be prepared to indicate, by suitable means, the general tolerances applicable to these curves and the conductor cross-sections used for establishing these curves (see 9.3.3.2.2, item c)).

NOTE It is recommended that the current be plotted as abscissa and the time as ordinates, using logarithmic scales. It is recommended that the current be plotted as multiples of the setting current and the time in seconds on the standard graph sheet detailed in 5.6.1 and Figure 1 of IEC 60269-1 and in Figure 104, Figure 504 and Figure 505 of IEC 60269-2.

5.7.6 Influence of ambient air temperature

The time-current characteristics (see 5.7.5) refer to a stated value of ambient air temperature, and are based on no previous loading of the overload relay (i.e. from an initial cold state). This value of the ambient air temperature shall be clearly given on the time curves; the preferred values are +20 °C or +40 °C.

The overload relays shall be able to operate within the ambient air temperature range of –5 °C to +40 °C, and the manufacturer shall be prepared to state the effect of variation in ambient air temperature on the characteristics of overload relays.

5.8 Co-ordination with short-circuit protective devices

The co-ordination of contactors and starters is characterized by the type, ratings and characteristics of the short-circuit protective devices (SCPD) that provide protection of the contactor and starter against short-circuit currents. Requirements are given in 8.2.5.1 and 8.2.5.2 of this standard, and in 4.8 of IEC 60947-1.

5.9 Void

5.10 Types and characteristics of automatic change-over devices and automatic acceleration control devices

5.10.1 Types

a) Time-delay devices, e.g. time-delay contactor relays (see IEC 60947-5-1) applicable to control-circuit devices or specified-time all-or-nothing relays (see IEC 61810-1).

b) Undercurrent devices (undercurrent relays).

c) Other devices for automatic acceleration control:

- devices dependent on voltage;
- devices dependent on power;

- devices dependent on speed.

5.10.2 Characteristics

a) The characteristics of time-delay devices are:

- the rated time-delay or its range, if adjustable;
- for time-delay devices fitted with a coil, the rated voltage, when it differs from the starter line voltage.

b) The characteristics of the undercurrent devices are:

- the rated current (thermal current and/or rated short-time withstand current, according to the indications given by the manufacturer);
- the current setting or its range, if adjustable.

c) The characteristics of the other devices shall be determined by agreement between manufacturer and user.

5.11 Types and characteristics of auto-transformers for two-step auto-transformer starters

Account being taken of the starting characteristics (see [5.3.5.5.3](#)), starting auto-transformers shall be characterized by:

- the rated voltage of the auto-transformer;
- the number of taps available for adjusting the starting torque and current;
- the starting voltage, i.e. the voltage at the tapping terminals, as a percentage of the rated voltage of the auto-transformer;
- the current they can carry for a specified duration;
- the rated duty (see [5.3.4](#));
- the method of cooling
 - air-cooling;
 - oil-cooling.

The auto-transformer can be:

- either built-in into the starter, in which case the resulting temperature rise has to be taken into account in determining the ratings of the starter;
- or provided separately, in which case the nature and dimensions of the connecting links have to be specified by agreement between the manufacturer of the transformer and the manufacturer of the starter.

5.12 Types and characteristics of starting resistors for rheostatic rotor starters

Account being taken of the starting characteristics (see [5.3.5.5.1](#)), the starting resistors shall be characterized by:

- the rated rotor insulation voltage (U_{ir});
- their resistance value;
- the mean thermal current, defined by the value of steady current they can carry for a specified duration;
- the rated duty (see [5.3.4](#));
- the method of cooling
 - free air;
 - forced air;
 - oil-immersion.

They can be:

- either built-in into the starter, in which case the resulting temperature rise has to be limited in order not to cause any damage to the other parts of the starter;
- or provided separately, in which case the nature and dimensions of the connecting links have to be specified by agreement between the manufacturer of the resistors and the manufacturer of the starter.

6 Product information

6.1 Nature of information

The following information shall be given by the manufacturer.

6.1.1 Identification

- a) manufacturer's name or trade mark;
- b) type designation or serial number;
- c) number of this standard, if the manufacturer claims compliance.

6.1.2 Characteristics, basic rated values and utilization

Characteristics:

- d) rated operational voltages (see [5.3.1.1](#));
- aa) polarity of terminals, if applicable;

e) utilization category and rated operational currents (or rated powers), at the rated operational voltages of the equipment (see [5.3.2.5](#) and [5.4](#));

f) either the value of the rated frequency 50/60 Hz or the symbol $\overline{\text{--}}$, or other rated frequencies e.g. 16 2/3 Hz, 400 Hz;

g) rated duty with the indication of the class of intermittent duty, if any (see [5.3.4](#)), and the off time as specified in footnote d) of [Table 10](#), if necessary.

Associated values:

h) rated making and breaking capacities. These indications may be replaced, where applicable, by the indication of the utilization category (see [Table 7](#)).

NOTE 1 Other information such as the pole impedance could be given e.g. in the product literature.

Safety and installation:

i) rated insulation voltage (see [5.3.1.2](#));

j) rated impulse withstand voltage (see [5.3.1.3](#));

k) IP code, in case of an enclosed equipment (see [8.1.11](#));

l) pollution degree (see [Clause 7](#)); m)

m) – for contactor or starter: rated conditional short-circuit current (see [5.3.6](#)) and type of co-ordination (see [8.2.5.1](#)) and type, current rating and characteristics of the associated SCPD;

– for combination starter, combination switching device, protected starter or protected switching device: rated conditional short-circuit current (see [5.3.6](#)) and type of co-ordination (see [8.2.5.1](#));

n) void.

Control circuits:

The following information concerning control circuits shall be placed either on the coil or on the equipment:

o) rated control circuit voltage (U_c), nature of current and rated frequency;

NOTE 2 Other information such as the holding or pick-up power could be given e.g. in the product literature.

p) if necessary, nature of current, rated frequency and rated control supply voltage (U_s).

Air supply systems for starters or contactors operated by compressed air:

q) rated supply pressure of the compressed air and limits of variation of this pressure, if they are different from those specified in [8.2.1.2](#).

Auxiliary circuits:

r) ratings of auxiliary circuits (see [5.6](#)).

Overload relays and releases:

s1) characteristics according to [5.7.2](#), [5.7.5](#) and [5.7.6](#);

s2) characteristics according to [5.7.3](#) and [5.7.4](#).

Additional information for certain types of contactor and starter:

Rheostatic rotor starters:

t) circuit diagram;

u) severity of start (see [5.3.5.5.1](#));

v) starting time (see [5.3.5.5.1](#)).

Auto-transformer starters:

w) rated starting voltage(s), i.e. voltage(s) at the tapping terminals.

NOTE 3 This value may be expressed as a percentage of the rated operational voltage of the starter.

Vacuum contactors and starters:

x) maximum permissible altitude of the site of installation, if less than 2 000 m.

EMC:

y) environment A or B: see 7.3.1 of IEC 60947-1;

z) special requirements, if applicable, for example shielded or twisted conductors.

NOTE 4 Unshielded or untwisted conductors are considered as normal installation conditions.

6.1.2DV D2 Modification of 6.1.2 as follows:

6.1.2DV.1 Delete Items c), m), q) and x):

These Items do not apply.

6.1.2DV.2 For item e), see [Table 5.4.1DV](#) for required marking.

6.1.2DV.3 Items h), i), r), y) and z) are optional.

6.1.2DV.4 Item j) is optional except when evaluating creepage and clearance distances per subclause 7.1.4 of CSA C22.2 No. 60947-1/UL 60947-1.

6.1.2DV.5 Item k) is optional and may be in addition to the required enclosure type ratings according to 7.1.12DV of CSA C22.2 No. 60947-1/UL 60947-1.

6.1.2DV.6 Item l) is only required if the pollution degree is other than pollution degree 3.

6.2 Marking

Subclause 5.2 of IEC 60947-1 applies to contactors, starters and overload relays with the following additions.

Data under items d) to x) in [6.1.2](#) shall be included on the nameplate or on the equipment or in the manufacturer's published literature.

Data under items c) in [6.1.1](#), aa), k) and s2) in [6.1.2](#) shall be marked on the equipment; timecurrent characteristics (or range of characteristics) may be provided in the manufacturer's published literature.

In the case of electronically controlled electromagnets, information other than that given in o) and p) of [6.1.2](#) may also be necessary; see also 5.5 and Annex U of IEC 60947-1:2007, Amendment 1.

NOTE In the USA and Canada, on multiple equipment, the additional category designation given in [Table 1](#) is marked on the product.

6.2DV D2 Add Subclauses 6.2DV.1 to 6.2DV.4 and Table 6.2DV.1 to Clause 6.2 as follows:

6.2DV.1 Markings

Locations of required markings shall be as shown in [Table 6.2DV.1](#).

**Table 6.2DV.1
Markings**

(6.2DV.1)

Clause reference	Required marking ^a	Location ^b	
		Enclosed	Open
Motor controllers			
6.1.1 a) and b)	Manufacturer name or trademark, model number or equivalent	A	A
6.1.2 d) – g), 6.1.2DV h), 6.1.2DV.2	Electrical ratings and associated information	A	A
6.1.2DV i) and j)	Rated insulation and impulse voltage	D	D
6.1.2 k)	IP rating	D	D
6.1.2 l)	Pollution degree (if other than pollution degree 3)	C	C
6.1.2 o) and p)	Control circuit electrical ratings	A	A
6.1.2DV r)	Auxiliary circuit electrical ratings	C	C
6.1.2DV k)	Environmental Type rating	A	–
6.2DV.2.1	Motor controller standard fault and high fault short-circuit current rating / protective device / Group installation	A	C
6.2DV.2.4	Motor controller for use with specific overload relay	B	B
6.2DV.2.5	Motor controllers for use on the load side of manual motor controllers suitable for tap conductor protection in group installations (United States only)	A	B
Cautionary markings for motor controllers ^c			

Table 6.2DV.1 Continued on Next Page

Table 6.2DV.1 Continued

Clause reference	Required marking ^a	Location ^b	
		Enclosed	Open
6.2DV.2.2	Marking for motor controllers having high available fault current rating	A	B
6.2DV.2.3	Control with limited terminal size for a direct current motor rating	A	B
Overload relays			
6.1.2 s1)	Time-current characteristics and influence of ambient	D	D
6.1.2 s2)	Electrical ratings, type, class, reset, current	A	A
6.1.2 s2), 5.7.3DV	Thermal memory	C	C
6.2DV.3.1	Automatic restart of motor	A	C
6.2DV.3.2	Current transformer for use with electronic overload relays	C	C
Cautionary markings for overload relays ^c			
6.2DV.3.3, 6.2DV.3.4	Marking for overload relay with replaceable type thermal elements having calibrated current sensing element	A	B
Table 8.2.2DV, Footnote b	Fuse replacement, Class G or K	A	A
Reduced voltage autotransformer controllers			
6.2DV.4	Marking for heavy or medium duty controllers	A	A
Rheostatic rotor starters			
6.1.2 t) – v)	Circuit diagram, severity of start, starting time	C	C
Auto-transformer starters			
6.1.2 w)	Rated starting voltage(s)	A	A
^a This is a brief summary of marking requirements. For complete details, see the specific Marking Reference. ^b For marking locations identified below, "A" is considered the highest order of location, and "D" is considered the lowest order of location. At the option of the manufacturer, a higher order of location category may be used. <ul style="list-style-type: none"> A. Enclosed Devices: Marking shall be on the product and visible when the enclosure cover is removed or the door is open. Open Devices: Marking shall be on the product. B. Marking provided on an adhesive-backed label shipped separately with the product. C. Marking is shipped with the product. D. Information available from the manufacturer. ^c Cautionary markings – Cautionary markings shall be located on a part that is not capable of being removed without impairing the operation or appearance of the equipment. A cautionary marking intended to instruct the operator shall be legible and visible to the operator during normal operation of the equipment. A marking that provides servicing instructions shall be legible and visible when such servicing is being performed.			

6.2DV.2 Motor controller markings

6.2DV.2.1 A motor control device, an overload relay, or equipment incorporating an overload relay shall be marked to indicate the maximum level of short-circuit testing, Type 2 co-ordination if applicable, and the intended short-circuit protective devices used in the installation:

- a) For devices subjected to standard fault short-circuit test only, the short-circuit current and voltage rating shall be marked, "Suitable For Use On A Circuit Capable Of Delivering Not More Than _____ rms Symmetrical Amperes, _____ Volts Maximum".

b) For devices subjected to group installation short-circuit tests, the devices shall be marked, "Suitable for motor group installation" in addition to the marking in Item (a).

c) For devices subjected to high fault short-circuit tests, the marking in Item (a) or (b) shall also include the following:

1) When Protected by _____ Class Fuses" or

2) "When Protected By A Circuit Breaker Having An Interrupting Rating Not Less Than _____ rms Symmetrical Amperes, _____ Volts Maximum".

d) When the short-circuit tests are conducted with fuses only, the marking in Item (a) or (b) shall include "Use Fuses Only".

e) When short-circuit tests are conducted with a protective device with an ampere rating less than the maximum capable of being used for the short-circuit test, the marking shall additionally include the type of protective device used and the maximum size of the protective device.

f) When standard fault short-circuit tests are conducted with a fuse size of 600 A and other than class RK5, the marking shall include "When Protected by _____ Class Fuses".

g) When tested in accordance with Type 2 co-ordination requirements, the marking may be followed by "Type 2 co-ordination" or equivalent. This marking may be on the product or the manufacturer's instructions.

6.2DV.2.2 Motor controllers intended for use on circuits having high available fault currents shall be marked with the word "WARNING" and the following or equivalent:

The opening of the branch-circuit protective device may be an indication that a fault current has been interrupted. To reduce the risk of fire or electric shock, current-carrying parts and other components of the controller shall be examined and replaced if damaged.

In Canada, the equivalent French wording is as follows:

AVERTISSEMENT – L'ouverture du dispositif de protection de la dérivation peut signifier qu'un courant de défaut a été interrompu. Pour réduire le risque d'incendie ou de choc électrique, les pièces porteuses de courant et autres composants du contrôleur devraient être examinées et remplacées s'ils sont endommagés.

This marking may be combined with [6.2DV.3.3](#).

6.2DV.2.3 A controller with direct-current motor ratings that does not comply with the requirements in 7.1.8.2DV.2 of CSA C22.2 No. 60947-1/UL 60947-1 shall be marked with the word "WARNING" and the following or equivalent:

Do not connect to a circuit supplied by a single-phase, half-wave rectifier.

or

Do not connect to a circuit supplied by a single-phase rectifier of the half-wave or full wave type.

In Canada, the equivalent French wording is as follows :

AVERTISSEMENT – Ne pas raccorder à un circuit alimenté par un redresseur à simple alternance monophasé.

or

AVERTISSEMENT – Ne pas raccorder à un circuit alimenté par un redresseur monophasé de type à simple alternance ou de type à deux alternances.

6.2DV.2.4 A motor controller evaluated for use only with a specific overload relay per Clause [8.2.5.1DV.2](#) shall be marked with the manufacturer's name and part number of the overload relay(s) to be used.

6.2DV.2.5 In the United States, when a motor controller has been evaluated for group installations on the load side of a manual motor controller suitable for tap conductor protection in group installations in accordance with [9.3.4.2DV.1.6](#), the motor controller shall be marked as follows:

(A) suitable for group installation on the load side of (B)

or the equivalent, where (A) and (B) are the manufacturer name and model number of the motor controller and manual motor controller respectively.

6.2DV.3 Overload relay markings

6.2DV.3.1 Industrial control equipment employing an automatic reset overload relay and a wiring diagram indicating 2-wire control shall be marked to indicate that a motor connected to the circuit will start automatically when the relay is in the automatic reset position.

6.2DV.3.2 If the overload relay is not provided with the intended current transformer, the overload relay shall be marked with the model or catalog number of the current transformer, or turns ratio, frequency and maximum signal (current) that can be applied to the input of the overload relay.

6.2DV.3.3 Except as permitted in [6.2DV.3.4](#), an overload relay that has a replaceable current element, or industrial control equipment incorporating such an overload relay, shall be permanently marked with the following or equivalent wording:

WARNING: THE OVERLOAD RELAY MUST BE REPLACED IF BURNOUT OF THE CURRENT ELEMENT OCCURS.

In Canada, the equivalent French marking is

AVERTISSEMENT: LE RELAIS DE SURCHARGE DOIT ÊTRE REMPLACÉ EN CAS DE GRILLAGE DE L'ÉLÉMENT TRAVERSE PAR LE COURANT.

6.2DV.3.4 If the calibrated elements of the overload relay described in [6.2DV.3.3](#) are contained within the replaceable thermal unit, then only the thermal unit needs to be replaced upon heater burnout. The marking of [6.2DV.3.3](#) may be modified to indicate that only the replacement of the thermal element is required.

6.2DV.4 Marking for reduced voltage autotransformer controllers

A reduced voltage autotransformer controller complying with the performance requirements in [Table 9.3.3.6DV.6.2.1.1](#) shall be marked "Heavy Duty" or "Medium Duty" as applicable for the intended use.

6.3 Instructions for installation, operation and maintenance

Subclause 5.3 of IEC 60947-1 applies with the following addition.

Information shall be provided by the manufacturer to advise the user on the measures to be taken with regard to the equipment in the event of a short-circuit and the measures to be taken with regard to the equipment, if any, concerning EMC.

In the case of protected starters, the manufacturer shall also provide the necessary mounting and wiring instructions.

The manufacturer of a starter incorporating an automatic reset overload relay capable of being connected to enable automatic restarting, shall provide, with the starter, that information necessary to alert the user to the possibility of automatic restarting.

7 Normal service, mounting and transport conditions

Clause 6 of IEC 60947-1 applies with the following addition.

Unless otherwise stated by the manufacturer, a contactor or a starter is for use in pollution degree 3 environmental conditions, as defined in 6.1.3.2 of IEC 60947-1. However, other pollution degrees may be considered to apply, depending upon the micro-environment.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

Subclause 7.1.1 of IEC 60947-1 applies.

8.1.2 Materials

8.1.2.1 General materials requirements

Subclause 7.1.2.1 of IEC 60947-1 applies

8.1.2.2 Glow wire testing

Subclause 7.1.2.2 of IEC 60947-1 applies with the following addition.

When tests on the equipment or on sections taken from the equipment are used, parts of insulating materials necessary to retain current-carrying parts in position shall conform to the glow-wire tests of 8.2.1.1.1 of IEC 60947-1 at a test temperature of 850 °C.

8.1.2.3 Test based on flammability category

Subclause 7.1.2.3 of IEC 60947-1 applies.

8.1.3 Current-carrying parts and their connections

Subclause 7.1.3 of IEC 60947-1 applies.

8.1.4 Clearances and creepage distances

Subclause 7.1.4 of IEC 60947-1 applies.

8.1.4DV D2 Modification of 8.1.4 by adding the following:

Creepage and clearance distances at field wiring terminals shall be evaluated in accordance with Annex [DVD](#). Where the design of the field wiring terminals is such that it precludes the possibility of reduced spacing due to stray strands or improper wiring installation, subclause 7.1.4 of CSA C22.2 No. 60947-1/UL 60947-1 may be used. Creepage and clearance distances at other than field wiring terminals shall be evaluated in accordance with Annex DVD or subclause 7.1.4 of CSA C22.2 No. 60947-1/UL 60947-1.

8.1.5 Actuator

Subclause 7.1.5 of IEC 60947-1 applies with the following addition.

Means for padlocking the operating handle of the manually operated switching device of a combination starter may be provided.

8.1.5.1 Insulation

Subclause 7.1.5.1 of IEC 60947-1 applies.

8.1.5.2 Direction of movement

Subclause 7.1.5.2 of IEC 60947-1 applies.

8.1.5.2DV D2 Modification of 8.1.5.2 by replacing it with the following:

Where a circuit breaker or switch is mounted such that movement of the operating handle, either vertically or rotationally, between the ON and OFF positions results in one position being above the other position, the upper position shall be the ON position. The requirement does not apply to a circuit breaker or switch that is operated horizontally or that is operated rotationally and the ON and OFF positions are at the same level, nor to a switching device having two ON positions, such as a transfer switch or a double throw switch.

8.1.5.3 Mounting

Actuators mounted on removable panels or opening doors shall be so designed that, when the panels are replaced or the doors closed, the actuator will engage correctly with the associated mechanism.

8.1.6 Indication of the contact position

8.1.6.1 Indicating means

Subclause 7.1.6.1 of IEC 60947-1 applies to manually operated starters.

8.1.6.1DV D2 *Modification of 8.1.6.1 by adding the following:*

The requirements regarding colours of push buttons, illuminated push buttons, and indicator lights are informative.

8.1.6.2 Indication by the actuator

Subclause 7.1.6.2 of IEC 60947-1 applies.

8.1.7 Additional requirements for equipment suitable for isolation

Subclause 7.1.7 of IEC 60947-1 applies.

8.1.8 Terminals

Subclause 7.1.8 of IEC 60947-1 applies with, however, the following additional requirements.

8.1.8.1 Terminal identification and marking

Subclause 7.1.8.4 of IEC 60947-1 applies with additional requirements as given in Annex [A](#).

8.1.9 Additional requirements for equipment provided with a neutral pole

Subclause 7.1.9 of IEC 60947-1 applies.

8.1.10 Provisions for protective earthing

Subclause 7.1.10 of IEC 60947-1 applies.

8.1.11 Enclosures for equipment

8.1.11.1 Design

Subclause 7.1.11.1 of IEC 60947-1 applies with the following additions.

Starting resistors mounted within an enclosure shall be so located or guarded that issuing heat is not detrimental to other apparatus and materials within the enclosure.

For the specific case of combination starters, the cover or door shall be interlocked so that it cannot be opened without the manually operated switching device being in the open position.

However, provision may be made to open the door or cover with the manually operated switching device in the ON position by the use of a tool.

8.1.11.1DV D2 Modification of 8.1.11.1 by adding the following:

8.1.11.1DV.1 The door interlock defeat mechanism shall be self-restoring when the door is closed.

8.1.11.1DV.2 The door interlock mechanism shall be arranged such that the door is required to be closed before the disconnecting means can be switched to the closed (ON) position. The door is not required to comply with the requirement when the interlocking means is intentionally defeated.

8.1.11.2 Insulation

Subclause 7.1.11.2 of IEC 60947-1 applies.

8.1.12 Degrees of protection of enclosed equipment

Subclause 7.1.12 of IEC 60947-1 applies.

8.1.13 Conduit pull-out, torque and bending with metallic conduits

Subclause 7.1.13 of IEC 60947-1 applies.

8.2 Performance requirements

8.2.1 Operating conditions

8.2.1.1 General

Subclause 7.2.1.1 of IEC 60947-1 applies with the following additions.

8.2.1.1.1 General conditions A

Starters shall be so constructed that they:

- a) are trip free;
- b) can be caused to open their contacts by the means provided when running and at any time during the starting sequence;
- c) will not function in other than the correct starting sequence.

8.2.1.1.2 General conditions B

Starters employing contactors shall not trip due to the shocks caused by operation of the contactors when tested according to [9.3.3.1](#), after the starter has carried its rated full load current at the reference ambient temperature (i.e. +20 °C) and has reached thermal equilibrium at both minimum and maximum settings of the overload relay, if adjustable.

8.2.1.1.3 General conditions C

For rheostatic starters, the overload relay shall be connected in the stator circuit. Special arrangements may be made to protect the rotor contactors and resistors against overheating, if requested by the user.

8.2.1.1.4 General conditions D

When starters are used in conditions in which the overheating of the starting resistors or transformers would represent an exceptional hazard, it is recommended that a suitable device be fitted to switch off the starter automatically before a dangerous temperature is reached.

8.2.1.1.5 General conditions E

The moving contacts of multipole equipment intended to make and break together shall be so coupled that all poles make and break substantially together, whether operated manually or automatically.

8.2.1.2 Limits of operation of contactors and power-operated starters

Subclause 7.2.1.2 of IEC 60947-1:2007 applies with following additions:

For latched contactors, the device shall drop out and open fully when a de-latching voltage between 85 % and 110 % of the rated de-latching voltage is applied.

8.2.1.3 Limits of operation of under-voltage relays and releases

Subclause 7.2.1.3 of IEC 60947-1 applies with the following addition: tests are specified in [9.3.3.2.2](#) of this standard.

8.2.1.3DV D2 Modification of 8.2.1.3 by adding the following:

Software and firmware critical to the limits of operation of undervoltage relays and releases is considered to be addressed by this testing.

8.2.1.4 Limits of operation of shunt-coil operated releases (shunt trip)

Subclause 7.2.1.4 of IEC 60947-1 applies with the following addition: tests are specified in [9.3.3.2.2](#) of this standard.

8.2.1.5 Limits of operation of current sensing relays and releases

8.2.1.5.1 Limits of operation of time-delay overload relays when all poles are energized

8.2.1.5.1.1 General tripping requirements of overload relays

NOTE 1 The thermal protection of motors in the presence of harmonics in the supply voltage is under consideration.

The relays shall comply with the requirements of [Table 3](#) when tested as follows:

a) with the overload relay or starter in its enclosure, if normally fitted, and at A times the current setting, tripping shall not occur in less than 2 h starting from the cold state, at the value of reference ambient air temperature stated in [Table 3](#). However, when the overload relay terminals have reached thermal

equilibrium at the test current in less than 2 h, the test duration can be the time needed to reach such thermal equilibrium;

b) when the current is subsequently raised to B times the current setting, tripping shall occur in less than 2 h;

c) for class 2, 3, 5 and 10A overload relays energized at C times the current setting, tripping shall occur in less than 2 min starting from thermal equilibrium, at the current setting, in accordance with 9.3.3 of IEC 60034-1; for class 10 A overload relays, for ambient air temperature $-5\text{ }^{\circ}\text{C}$ or below, the manufacturer may declare a longer tripping time but not longer than 2 times the values required for $20\text{ }^{\circ}\text{C}$;

NOTE 2 Subclause 9.3.3 of IEC 60034-1 states: "Polyphase motors having rated outputs not exceeding 315 kW and rated voltages not exceeding 1 kV shall be capable of withstanding a current equal to 1,5 times the rated current for not less than 2 min".

d) for class 10, 20, 30 and 40 overload relays energized at C times the current setting, tripping shall occur in less than 4, 8, 12 or 16 min respectively, starting from thermal equilibrium, at the current setting;

e) at D times the current setting, tripping shall occur within the limits given in [Table 2](#) for the appropriate trip class and tolerance band, starting from the cold state.

In the case of overload relays having a current setting range, the limits of operation shall apply when the relay is carrying the current associated with the maximum setting and also when the relay is carrying the current associated with the minimum setting.

For non-compensated overload relays, the current multiple/ambient temperature characteristic shall not be greater than 1,2 %/K.

NOTE 3 1,2 %/K is the derating characteristic of PVC-insulated conductors.

An overload relay is regarded as compensated if it complies with the relevant requirements of [Table 3](#) at $+20\text{ }^{\circ}\text{C}$ and is within the limits shown in [Table 3](#) at other temperatures.

8.2.1.5.1.1DV.1 D2 Modification of 8.2.1.5.1.1 by adding the following to Item b):

For non-compensated overload relays, the manufacturer may declare a trip level higher than that in [Table 3](#), Column B, for ambient temperatures from $20\text{ }^{\circ}\text{C}$ to $40\text{ }^{\circ}\text{C}$. In this case, the test value at $20\text{ }^{\circ}\text{C}$ shall be that declared by the manufacturer;

8.2.1.5.1.1DV.2 D2 Modification of 8.2.1.5.1.1 by adding the following to Item d):

Overload relays may alternatively be energized at 200 % of the rated tripping current, starting from a cold state. Tripping shall occur in 8 minutes or less;

8.2.1.5.1.1DV.3 D2 Modification of 8.2.1.5.1.1 by replacing Item e) with the following:

e) at D times the current setting, tripping shall occur within the maximum time limits given in [Table 2](#) for the appropriate trip class, starting from the cold state. The minimum values given in [Table 2](#) are informative only.

8.2.1.5.1.1DV.4 D2 Modification of 8.2.1.5.1.1 by replacing the second paragraph following Item e) with the following:

The current multiple/ambient temperature characteristic is informative.

Table 3
Limits of operation of time-delay overload relays when energized on all poles

Type of overload relay	Multiples of current setting				Ambient air temperature values
	A	B	C	D	
Thermal type not compensated for ambient air temperature variations	1,0	1,2 ^b	1,5	7,2	+40 °C
Thermal type compensated for ambient air temperature variations	c	c	—	—	less than -5 °C ^a
	1,05	1,3	1,5	—	-5 °C
	1,05	1,2 ^b	1,5	7,2	+20 °C
	1,0	1,2 ^b	1,5	—	+40 °C
	c	c	—	—	more than +40 °C ^d
Electronic type ^a	1,05	1,2 ^b	1,5	7,2	0 °C, +20 °C and +40 °C

^a This test shall only be done at 20 °C for A, B and D multiples of current setting.

^b If specified by the manufacturer, the tripping current could be different from 120 % but shall not exceed 125 %. In this case the test current value shall be equal to this tripping current value. In this case, the tripping current value shall be marked on the device.

^c Multiples of current setting should be declared by the manufacturer.

^d See 9.3.3.2.2 for tests outside the -5 °C +40 °C range.

8.2.1.5.1.2 Thermal memory test verification

Unless the manufacturer has specified that the device does not contain thermal memory, electronic overload relays shall fulfil the following requirements (see [Figure 8](#)):

- apply a current equal to I_e until the device has reached the thermal equilibrium;
- interrupt the current for a duration of $2 \times T_p$ (see [Table 2](#)) with a relative tolerance of ± 10 % (where T_p is the time measured at the D current according to [Table 3](#));
- apply a current equal to $7,2 \times I_e$;
- the relay shall trip within 50 % of the time T_p .

8.2.1.5.2 Limits of operation of three-pole time-delay overload relays energized on two poles

With reference to [Table 4](#):

The overload relay or starter shall be tested in its enclosure if normally fitted. With the relay energized on three poles, at A times the current setting, tripping shall not occur in less than 2 h, starting from the cold state, at the value of the ambient air temperature stated in [Table 4](#).

Moreover, when the value of the current flowing in two poles (in phase loss sensitive relays, those carrying the higher current) is increased to B times the current setting, and the third pole de-energized, tripping shall occur in less than 2 h.

The values shall apply to all combinations of poles.

In the case of overload relays having an adjustable current setting, the characteristics shall apply both when the relay is carrying the current associated with the maximum setting and when the relay is carrying the current associated with the minimum setting.

8.2.1.5.2DV D2 *Modification of 8.2.1.5.2 by adding the following:*

Overload relays may alternatively be energized at 200 percent of the rated tripping current, starting from a cold state. Tripping shall occur in 8 minutes or less.

Table 4
Limits of operation of three-pole time-delay overload relays when energized on two poles only

Type of overload relay	Multiples of current setting		Reference ambient air temperature
	A	B	
Thermal, compensated for ambient air temperature variations or electronic Not phase loss sensitive	3 poles 1,0	2 poles 1,32 1 pole 0	+20 °C
Thermal, not compensated for ambient air temperature variations Not phase loss sensitive	3 poles 1,0	2 poles 1,25 1 pole 0	+40 °C
Thermal, compensated for ambient air temperature variations or electronic Phase loss sensitive	2 poles 1,0 1 pole 0,9	2 poles 1,15 1 pole 0	+20 °C

8.2.1.5.3 Limits of operation of instantaneous magnetic overload relays

For all values of the current setting, instantaneous magnetic overload relays shall trip with an accuracy of $\pm 10\%$ of the value of the published current value corresponding to the current setting.

NOTE Magnetic instantaneous overload relays covered by this standard are not intended for short-circuit protection.

8.2.1.5.4 Limits of operation of under-current relays and releases for automatic change over

8.2.1.5.4.1 Limits of operation of under-current relays

An under-current relay or release, when associated with a switching device, shall operate to open the switching device within 80 % to 120 % of the set time, when the current during operation is below 0,9 times the under current setting in all poles. When the operating time is below 1 s, a different tolerance may be given by the manufacturer but the upper limit shall not exceed 1,2 s.

NOTE The tolerance depends on the sensing technology.

8.2.1.5.4.2 Limits of operation of automatic change over by under-current relays

This subclause applies to:

- star-delta starters from star to delta, and
- auto-transformer starters from the starting to the ON position.

The lowest drop-out current of an under-current relay shall be not greater than 1,5 times the actual current setting of the overload relay which is active in the starting or star connection. The under-current relay shall be able to carry any value of current, from its lowest current setting to the stalled current in the starting position or the star connection, for the tripping times determined by the overload relay at its highest current setting.

8.2.1.5.4.2DV D2 Modification of 8.2.1.5.4.2 by addition of the following:

This subclause is informative.

8.2.1.5.5 Limits of operation of stall relays

A stall relay, when associated with a switching device, shall operate to open the switching device within 80 % to 120 % of the set time (stall inhibit time) or within the accuracy specified by the manufacturer, when:

- a) current sensing relays: the current is 20 % higher than the set stall current value;

EXAMPLE Set current of the stall relay: 100 A; set time: 6 s; accuracy: $\pm 10\%$, the relay shall trip within 5,4 s and 6,6 s when the current is equal to or greater than $100\text{ A} \times 1,2 = 120\text{ A}$.

- b) rotation sensing relays: an input signal indicating no motor rotation exists.

8.2.1.5.6 Limits of operation of jam relays and releases

A jam relay or release, when associated with a switching device, shall operate to open the switching device within 80 % to 120 % of the set time (jam inhibit time) or within the accuracy specified by the manufacturer, when the current is above 1,2 times the set current value of the jam relay, during running after completion of the starting.

8.2.2 Temperature rise

8.2.2DV D2 Modification of 8.2.2 by replacing it and all subclauses with the following text and Table 8.2.2DV:

In addition to complying with the requirements of the temperature test in 7.2.2DV of CSA C22.2 No. 60947-1/UL 60947-1, the temperature rises shall not exceed those given in [Table 8.2.2DV](#).

Table 8.2.2DV
Maximum temperature rises^a

([8.2.2DV](#) and [DVC.5.1.1.3](#))

Materials and components		K
1.	Knife-switch blades and contact jaws	30
2.	Fuse clip tested with a dummy fuse representing a branch circuit fuse	30
3.	Fuse clip when tested with a fuse intended to provide branch circuit protection ^b	85
4.	Insulation systems:	
	Class 105 insulation system	85 ^c
	Class 105(A) insulation systems on single-layer series coil with exposed surfaces either uninsulated or enameled, thermocouple method	90
	Class 120(E) insulation system ^d	95 ^c
	Class 130(B) insulation systems ^d	105 ^c
	Class 155(F) insulation systems ^d	115 ^c
	Class 180(H) insulation systems ^d	135 ^c
	Class 200(N) insulation systems ^d	155 ^c
	Class 220(R) insulation systems ^d	175 ^c
^a For equipment rated for an ambient temperature other than 40 °C, the allowable temperature rises in this table shall be adjusted in accordance with the following formula:		
$T_R = T_T + 40\text{ °C} - T_M$		
in which:		
T_R = Allowable temperature rise;		
T_T = Maximum temperature rise allowed by Table 8.2.2DV ; and		
T_M = Ambient temperature marked on the equipment.		
^b When the fuse used to determine compliance with the fuse clip temperature rise requirement is a Class G or K, there shall be a marking near the fuse holder specifying the class of the replacement fuse.		
^c Values shown are for the change of resistance method. For thermocouple method subtract 20 from the temperature rise.		
^d The insulation system shall meet the requirements of UL 1446.		

8.2.2.1 General

The requirements of 7.2.2 of IEC 60947-1 apply to contactors and starters in a clean, new condition.

NOTE 1 Contact resistance due to oxidation may impact the temperature rise test at test voltages below 100 V. In the case of conducting the test at a voltage below 100 V, such devices may have the contacts cleaned either by any nonabrasive method or by carrying out 10 operating cycles under the conditions of [Table 10](#) for any applicable utilization category at any voltage.

The temperature rises of the several parts of the contactor or starter measured during a test carried out under the conditions specified in [9.3.3.3](#) shall not exceed the limiting values stated in [Table 5](#) of this standard and in 7.2.2.1 and 7.2.2.2 of IEC 60947-1.

In the case of an electronically controlled electromagnet, coil temperature measuring by variation of resistance may be impracticable; in such a case, other methods are permitted, e.g. thermocouples or other suitable methods.

Table 5
Temperature rise limits for insulated coils in air and in oil

Class of insulating material (according to IEC 60085)	Temperature rise limit (measured by resistance variation) K	
	Coils in air	Coils in oil
A	85	60
E	100	60
B	110	60
F	135	—
H	160	—

Because, in an auto-transformer starter, the auto-transformer is energized only intermittently, a maximum temperature rise of 15 K greater than the figures in [Table 5](#) is permissible for the windings of the transformer when the starter is operated according to the requirements of [5.3.4](#) and [5.3.5.5.3](#).

NOTE 2 The temperature rise limits given in [Table 5](#) of this standard and in 7.2.2.2 of IEC 60947-1 are applicable only if the ambient air temperature remains within the limits -5°C , $+40^{\circ}\text{C}$.

8.2.2.2 Terminals

Subclause 7.2.2.1 of IEC 60947-1 applies.

8.2.2.3 Accessible parts

Subclause 7.2.2.2 of IEC 60947-1 applies.

8.2.2.4 Ambient air temperature

Subclause 7.2.2.3 of IEC 60947-1 applies.

8.2.2.5 Main circuit

The main circuit of a contactor or a starter which carries current in the ON position, including the over-current releases which may be associated with it, shall be capable of carrying, without the temperature rises exceeding the limits specified in 7.2.2.1 of IEC 60947-1 when tested in accordance with [9.3.3.3.4](#):

- for a contactor or starter intended for continuous duty: its conventional thermal current (see [5.3.2.1](#) and/or [5.3.2.2](#));
- for a contactor or starter intended for uninterrupted duty, intermittent duty or temporary duty: its relevant rated operational current (see [5.3.2.5](#)).

8.2.2.6 Control circuits

Subclause 7.2.2.5 of IEC 60947-1 applies.

8.2.2.7 Windings of coils and electromagnets

8.2.2.7.1 Uninterrupted and eight-hour duty windings

With the maximum value of current according to [8.2.2.5](#) flowing through the main circuit, the windings of the coils, including those of electrically operated valves of electro-pneumatic contactors or starters, shall withstand, under continuous load and at the rated frequency, if applicable, their maximum rated control supply voltage without the temperature rise exceeding the limits specified in [Table 5](#) of this standard and in 7.2.2.6 of IEC 60947-1.

NOTE Depending on the technology, e.g. for some kinds of electronically controlled electromagnets, the control supply voltage may not be directly applied on the coil winding when connected as in normal service.

8.2.2.7.2 Intermittent duty windings

With no current flowing through the main circuit, the windings of the coils shall withstand, at the rated frequency, if applicable, their maximum rated control supply voltage applied as detailed in [Table 6](#) according to their intermittent duty class, without the temperature rise exceeding the limits specified in [Table 5](#) of this standard and in 7.2.2.2 of IEC 60947-1.

NOTE Depending on the technology, e.g. for some kind of electronically controlled electromagnet, the control supply voltage may not be directly applied on the coil winding when connected as in normal service.

Table 6
Intermittent duty test cycle data

Intermittent duty class		One close-open operating cycle every	Interval of time during which the supply to the control coil is maintained
Contactors	Starters		
1	1	3 600 s	“ON” time should correspond to the on-load factor specified by the manufacturer
3	3	1 200 s	
12	12	300 s	
30	30	120 s	
120		30 s	
300		12 s	
1 200		3 s	

8.2.2.7.3 Specially rated (temporary or periodic duty) windings

Specially rated windings shall be tested under operating conditions corresponding to the most severe duty for which they are intended and their ratings shall be stated by the manufacturer.

NOTE Specially rated windings may include coils of starters which are energized during the starting period only, trip coils of latched contactors and certain magnetic valve coils for interlocking pneumatic contactors or starters.

8.2.2.8 Auxiliary circuits

Subclause 7.2.2.7 of IEC 60947-1 applies.

8.2.2.9 Other parts

Subclause 7.2.2.8 of IEC 60947-1 applies, replacing words “plastics and insulating materials” with “insulating parts”.

8.2.3 Dielectric properties

Subclause 7.2.3 of IEC 60947-1:2007 applies with the following additions:

General requirements for device including voltage limiting components inserted between circuits not connected to the ground/earth to be tested according to the dielectric test are described as follows.

These voltage limiting components called varistors used in order to protect electronic parts from surges within the device shall comply with IEC 61051-2. In this clause, the intent is not to reduce the clearances. For the type test of the device the voltage limiting components may be disconnected.

IEC 61051-2 applies as follows:

a) Preferred climatic categories of the varistor:

- maximum lower temperature: -10 °C
- minimum upper temperature: +85 °C

The device manufacturer has to verify that the varistor is suitable for use in the extended ambient temperature if any.

b) The minimum rated voltage of the varistor shall be 1,2 times the maximum peak voltage where the varistor is connected.

c) When connected to the mains, varistors shall withstand the surge test according to [9.4.2.5](#).

NOTE 1 With the verification of the varistors above it is assumed that a fuse protecting the varistor is not necessary.

NOTE 2 The possibility given in 8.3.3.4.1 item 1) of IEC 60947-1:2007 of disconnecting circuits between poles may be not appropriate in the routine test, because the products are completed and it is not appropriate to reopen and manipulate them. The main purpose of this test is to identify the proper operation of the voltage limiting component.

8.2.3DV D2 Modification to 8.2.3 by replacing it with the following:

Subclause 7.2.3 of CSA C22.2 No. 60947-1/UL 60947-1 shall apply with the following addition:

Voltage limiting components shall comply with the requirements of 7.1.1DV.7 of CSA C22.2 No. 60947-1/UL 60947-1.

8.2.4 Normal load and overload performance requirements

Requirements concerning normal load and overload characteristics according to [5.3.5](#) are given in [8.2.4.1](#), [8.2.4.2](#) and [8.2.4.4](#).

8.2.4.1 Making and breaking capacities

Contactors or starters shall be capable of making and breaking currents without failure under the conditions stated in [Table 7](#) for the required utilization categories and the number of operations indicated, as specified in [9.3.3.5](#).

The off-time and on-time values given in [Table 7](#) and [Table 8](#) shall not be exceeded.

Table 7
Making and breaking capacities – Making and breaking conditions according to utilization category

Utilization category	Make and break conditions					
	I_c/I_e	U_r/U_e	$\cos \phi$	On-time ^b s	Off-time s	Number of operating cycles
AC-1	1,5	1,05	0,8	0,05	f	50
AC-2	4,0 ^h	1,05	0,65 ^h	0,05	f	50
AC-3 ⁱ	8,0	1,05	a	0,05	f	50
AC-4 ⁱ	10,0	1,05	a	0,05	f	50
AC-5a	3,0	1,05	0,45	0,05	f	50
AC-5b	1,5 ^c	1,05	c	0,05	60	50
AC-6a	j					
AC-6b	1,5 ^e	1,05		l	m	50
AC-8a ^k	6,0	1,05	a	0,05	f	50
AC-8b ^k	6,0	1,05	a	0,05	f	50
Utilization category	I_c/I_e	U_r/U_e	L/R ms	On-time ^b s	Off-time s	Number of operating cycles
DC-1	1,5	1,05	1,0	0,05	f	50 ^d
DC-3	4,0	1,05	2,5	0,05	f	50 ^d
DC-5	4,0	1,05	15,0	0,05	f	50 ^d
DV-6	1,5 ^c	1,05	c	0,05	60	50 ^d
Utilization category	Make conditions ⁱ					
	I/I_e	U/U_e	$\cos \phi$	On-time ^b s	Off-time s	Number of operating cycles
AC-3	10	1,05 ^g	a	0,05	10	50
AC-4	12	1,05 ^g	a	0,05	10	50

I = current made. The making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that, for a.c., the actual peak value during the making operation may assume a higher value than the symmetrical peak value.

I_c = current made and broken, expressed in d.c. or a.c. r.m.s. symmetrical values

I_e = rated operational current

U = applied voltage

U_r = power frequency or d.c. recovery voltage

U_e = rated operational voltage

$\cos \phi$ = power factor of test circuit

L/R = time-constant of test circuit

^a $\cos \phi = 0,45$ for $I_e \leq 100$ A; $0,35$ for $I_e > 100$ A.

^b The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before reopening.

^c Tests to be carried out with an incandescent light load.

^d If polarity not marked on the device, 25 operating cycles with one polarity and 25 operating cycles with reverse polarity.

^e The load shall consist of commercially available capacitor combinations to obtain a steady-state reactive current I_e calculated according to [9.3.3.3.4](#). Alternatively capacitive ratings may be derived by capacitor switching tests or assigned on the basis of

Table 7 Continued on Next Page

Table 7 Continued

established practice and experience. As a guide, reference may be made to the formula given in [Table 9](#) which does not take into account the thermal effects due to harmonic currents. The available current capacity at the test terminals shall not be less than the prospective current "I". It can be determined by analytical evaluation.

^f See [Table 8](#).

^g For U / U_e , a tolerance of $\pm 20\%$ is accepted.

^h The values shown are for stator contactors. For rotor contactors, the test shall be made with a current of four times the rated rotor operational current and a power factor of 0,95.

ⁱ The make conditions for utilization categories AC-3 and AC-4 shall also be verified. The verification may be made during the make and break test, but only with the manufacturer's agreement. In this case, the making current multiples shall be as shown for I / I_e and the breaking current as shown for I_c / I_e . 25 operating cycles shall be made at a control supply voltage equal to 110 % of the rated control supply voltage U_s and 25 operating cycles at 85 % of U_s . The off-times are to be determined from [Table 8](#).

^j The manufacturer shall verify the AC-6a rating by testing with a transformer or may derive the rating from the values for AC-3 according to [Table 9](#).

^k A lower ratio of I_c / I_e (locked rotor to full load current) may be used if specified by the manufacturer.

^l The on time shall be long enough in order to reach the stabilized current.

^m Off-time according to [Table 8](#). The value of a discharge resistor shall be determined to reach less than 50 V at the end of off-time.

Table 8
Relationship between current broken I_c and off-time for the verification of rated making and breaking capacities

Current broken I_c A	Off-time s
$I_c \leq 100$	10
$100 < I_c \leq 200$	20
$200 < I_c \leq 300$	30
$300 < I_c \leq 400$	40
$400 < I_c \leq 600$	60
$600 < I_c \leq 800$	80
$800 < I_c \leq 1\,000$	100
$1\,000 < I_c \leq 1\,300$	140
$1\,300 < I_c \leq 1\,600$	180
$1\,600 < I_c$	240

The off-time values may be reduced if agreed by the manufacturer.

Table 9

Operational current determination for utilization categories AC-6a and AC-6b when derived from AC-3 ratings

Rated operational current	Determination from making current for utilization category AC-3
I_e (AC-6a) for switching of transformers having inrush current peaks of not more than 30 times peak of rated current	$0,45 I_e$ (AC-3)
I_e (AC-6b) for switching of single capacitor banks in circuits having a prospective short-circuit current i_k at the location of the capacitor bank	$i_k \frac{x^2}{(x-1)^2}$ <p>with</p> $x = 13,3 \times \frac{I_e \text{ (AC-3)}}{i_k}$ <p>and for</p> $i_k > 205 I_e \text{ (AC-3)}$
<p>The expression for the operational current I_e (AC-6b) emanates from the formula for the highest inrush current peak:</p> $I_{pmax} = \frac{U_e \times \sqrt{2}}{\sqrt{3}} \times \frac{1 + \sqrt{\frac{X_c}{X_L}}}{X_L - X_c}$ <p>where</p> <p>U_e is the rated operational voltage;</p> <p>X_L is the short-circuit impedance of the circuit;</p> <p>X_c is the reactance of the capacitor bank.</p> <p>This formula is valid on condition that capacitance on the supply side of the contactor or starter can be neglected and that there is no initial charge on the capacitor.</p>	

s4451a

8.2.4.1DV D2 Modification of 8.2.4.1 by adding the following:

8.2.4.1DV.1 Overload test – Equipment with horsepower, resistance only, electric heating control, resistance air heating or elevator control ratings shall close and open a test circuit having the current and power factor as described in [Table 8.2.4.1DV.1.1](#) and tested according to [9.3.3.5.5DV](#). Equipment having a rating with an equivalent utilization category (see [Table 5.4.1DV](#)) and/or an AC-4 utilization category shall be tested in accordance with the respective conditions in [Table 7](#) and according to [9.3.3.5.5DV](#).

8.2.4.1DV.1.1 Overload test – Equipment with horsepower ratings may be tested in accordance with the requirements for AC3 utilization category per [8.2.4.1](#) in lieu of testing per [8.2.4.1DV.1](#). The test current values for the associated horsepower ratings shall be based on [Table G.1](#).

8.2.4.1DV.1.2 Overload test – Equipment with AC4 utilization category ratings (see [Table 5.4.1DV](#)) shall be tested in accordance with [8.2.4.1](#). The test current values for the associated horsepower ratings shall be based on [Table G.1](#).

8.2.4.1DV.1.3 Testing for incandescent lighting ratings (AC-5b and DC-6) may be conducted using synthetic loads instead of lamp loads. The synthetic loads shall have an inrush current of at least ten times the steady state current, and the peak value of the inrush current shall be reached within 1/240th of a second.

8.2.4.1DV.1.4 Testing for AC resistance air heating and DC resistance air heating shall be in accordance with [Table 8.2.4.1DV.1.1](#).

Table 8.2.4.1DV.1.1
Overload test circuit^{a,d}

([5.4.1DV](#), [8.2.4.1DV.1](#), [9.3.3.5.5DV.3](#), [9.3.3.5.5DV.4](#))

Intended device application	Current, amperes	Power factor
Across-the-Line a.c. Motor Starting, single phase (Hp or kW)	6 times device full-load current	0,40 – 0,50
Across-the-line a.c. Motor Starting, 2- and 3-phase (Hp or kW)	Locked rotor current ^e	0,40 – 0,50
Across-the-Line d.c. Motor Starting (Hp or kW)	10 times device full-load current ^b	d.c. ^b
DC Resistance only	1,5 times device rated value	d.c. ^b
AC Resistance only	1,5 times device rated value	1,0
AC Electric Heating Control	1,5 times device rated value	1,0
AC Resistance Air Heating	1,5 times device rated value	1,0
DC Resistance Air Heating	1,5 times device rated value	d.c. ^b
Elevator Control, a.c. ^c	–	–
Elevator Control, d.c. ^c	–	–

^a The test cycles shall be as described in [9.3.3.5.5DV.8](#).

^b Load shall be a non-inductive resistive load. See [G.1DV](#) for full load currents of DC motors.

^c No overload conditioning shall be required for an elevator control.

^d The equipment shall open and close the test circuit 50 times. A reversing controller shall be subjected to ten additional cycles of operation with both coils energized simultaneously after the 50 cycles of operation.

^e In Canada, locked rotor current is equal to six times the applicable full load current per Annex [G](#), [Table G.1](#) for 2- and 3-phase motors or [G.1DV](#) for single-phase motors. In the USA, locked rotor current shall be selected per Annex [G](#), [G.1DV](#) for 2- and 3-phase motors based on the rated horsepower.

8.2.4.2 Conventional operational performance

Subclause 7.2.4.2 of IEC 60947-1 applies with the following addition.

Contactors or starters shall be capable of making and breaking currents without failure under the conventional conditions stated in [Table 10](#) for the required utilization categories and the number of operating cycles indicated as specified in [9.3.3.6](#).

Table 10
Conventional operational performance – Making and breaking conditions according to utilization category

Utilization category	Make and break test conditions					
	I_c/I_e	U_r/U_e	$\cos \phi$	On-time s	Off-time s	Number of operating cycles
AC-1	1,0	1,05	0,80	0,05 ^b	c	6 000 ⁱ
AC-2	2,0	1,05	0,65	0,05 ^b	c	6 000 ⁱ
AC-3	2,0	1,05	a	0,05 ^b	c	6 000 ⁱ
AC-4	6,0	1,05	a	0,05 ^b	c	6 000 ⁱ
AC-5a	2,0	1,05	0,45	0,05 ^b	c	6 000 ⁱ
AC-5b	1,0 ^e	1,05	e	0,05 ^b	60	6 000 ⁱ
AC-6a	g	g	g	g	g	g
AC-6b	1 ^k	1,05		l	m	6 000
AC-8a	1,0	1,05	0,80	0,05 ^b	c	30 000
AC-8b ^{h,j}	6,0	1,05	a	1 10	9 90 ^d	5 900 100
Utilization category	I_c / I_e	U_r / U_e	L/R ms	On-time s	Off-time s	Number of operating cycles
DC-1	1,0	1,05	1,0	0,05 ^b	c	6 000 ^f
DC-3	2,5	1,05	2,0	0,05 ^b	c	6 000 ^f
DC-5	2,5	1,05	7,5	0,05 ^b	c	6 000 ^f
DC-6	1,0 ^e	1,05	e	0,05 ^b	60	6 000 ^f

I_c = current made or broken. Except for AC-5b, AC-6 or DC-6 categories, the making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that for a.c. the actual peak value during the making operation may assume a higher value than the symmetrical peak value.

I_e = rated operational current

U_r = power frequency or d.c. recovery voltage

U_e = rated operational voltage

$\cos \phi$ = power factor of test circuit

L / R = time-constant of test circuit

^a $\cos \phi = 0,45$ for $I_e \leq 100$ A; $0,35$ for $I_e > 100$ A.

^b The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before reopening.

^c These off-times shall be not greater than the values specified in [Table 8](#).

^d The manufacturer may choose any value for the Off-time up to 200 s.

^e Tests to be carried out with an incandescent light load.

^f If polarity not marked on the device, 3 000 operating cycles with one polarity and 3 000 operating cycles with reverse polarity.

Table 10 Continued on Next Page

Table 10 Continued

- ^g The manufacturer shall verify the AC-6a rating by testing with a transformer or may derive the rating from the values for AC-3 according to [Table 9](#).
- ^h Tests for category AC-8b shall be accompanied by tests for category AC-8a. The tests may be made on different samples.
- ⁱ For manually operated switching devices, the number of operating cycles shall be 1 000 on-load, followed by 5 000 off-load.
- ^j A lower ratio of I_c / I_e (locked rotor to full load current) may be used if specified by the manufacturer.
- ^k The load shall consist of commercially available capacitor combinations to obtain a steady-state reactive current I_e calculated according to [9.3.3.3.4](#). Alternatively capacitive ratings may be derived by capacitor switching tests or assigned on the basis of established practice and experience. As a guide, reference may be made to the formula given in [Table 9](#) which does not take into account the thermal effects due to harmonic currents. The available current capacity at the test terminals shall not be less than the prospective current " I'' ". It can be determined by analytical evaluation.
- ^l The on time shall be long enough in order to reach the stabilized current.
- ^m Off-time according to [Table 8](#). The value of a discharge resistor shall be determined to reach less than 50 V at the end of off-time.

8.2.4.2DV D2 Modification of 8.2.4.2 by adding the following:

8.2.4.2DV.1 Endurance test performance - Equipment with horsepower, resistance only, electric heating control, resistance air heating or elevator control ratings shall close and open a test circuit having the current and power factor as described in [Table 8.2.4.2DV.1.1](#) and tested according to Clause [9.3.3.6DV.1](#). Equipment having a rating with an equivalent utilization category (see [Table 5.4.1DV](#)) and/or an AC-4 utilization category shall be tested in accordance with the conditions in [Table 8](#) and according to [9.3.3.5](#).

8.2.4.2DV.1.1 Endurance test performance – Equipment with horsepower ratings may be tested in accordance with the requirements for AC3 utilization category per [8.2.4.2](#) in lieu of testing per Clause [8.2.4.2DV.1](#). The test current values for the associated horsepower ratings shall be based on [Table G.1](#).

8.2.4.2DV.1.2 Endurance test performance - Equipment with AC4 utilization category ratings (see [Table 5.4.1DV](#)) shall be tested in accordance with [8.2.4.2](#). The test current values for the associated horsepower ratings shall be based on [Table G.1](#).

8.2.4.2DV.1.3 Testing for incandescent lighting ratings (AC-5b and DC-6) may be conducted using synthetic loads instead of lamp loads. The synthetic loads shall have an inrush current of at least ten times the steady state current and the peak value of the inrush current shall be reached within 1/240th of a second.

Table 8.2.4.2DV.1.1
Endurance test ([5.4.1DV](#), [8.2.4.2DV.1](#), [9.3.3.6DV.2](#), [Table 9.3.3.6DV.1](#))

Intended device application	Test current, amperes	Power factor	Number of cycles	Test cycle, Seconds	
				On	Off
Across-the-Line a.c. Motor Starting (Hp or kW)	Twice Full-Load Current	0,40 – 0,50	1 000 ^a	b	b
Across-the-Line d.c. Motor Starting (Hp or kW)	Twice Full-Load Current	d.c. ^c	1 000 ^a	b	b
DC Resistance	Rated Current	d.c. ^c	6 000	1	9
AC Resistance	Rated Current	1,0	6 000	1	9

Table 8.2.4.2DV.1.1 Continued on Next Page

Table 8.2.4.2DV.1.1 Continued

Intended device application	Test current, amperes	Power factor	Number of cycles	Test cycle, Seconds	
				On	Off
AC Electric Heating Control	Rated Current	1,0	250 000	1	9
DC Resistance Air Heating	Rated Current	d.c. ^c	100 000	1	9
AC Resistance Air Heating	Rated Current	1,0	100 000	1	9
Elevator Control, a.c. motor	Twice Full-Load Current	0,40 – 0,50	500 000	1	9
Elevator Control, d.c. motor	Twice Full-Load Current	d.c. ^c	500 000	1	9
^a These devices shall be subjected to at least 6 000 mechanical cycles at any convenient rate.					
^b Other than as noted in note a, the test cycle shall be as indicated in Table 9.3.3.6DV.1 .					
^c Load is a non-inductive resistive load.					

8.2.4.2DV.2 Part winding endurance test – A controller for a 3-phase hermetic refrigerant motor-compressor equipped with a part winding motor of the type in which one-half of the winding is energized through a controller and, subsequently or simultaneously through a second controller, the remaining half is energized so that both halves carry the same running current, shall be tested for the application as shown in [Table 8.2.4.2DV.2.1](#) or [Table 8.2.4.2DV.2.2](#). If the circuit does not contain a feature to delay the energization of the second controller, [Table 8.2.4.2DV.2.1](#) shall be used for both controllers. If the circuit is provided with a feature to delay the energization of the second controller, [Table 8.2.4.2DV.2.2](#) shall be used for the first controller and [Table 8.2.4.2DV.2.1](#) shall be used for the second (delayed) controller. The controller shall comply with these requirements in addition to the requirements for the device.

Table 8.2.4.2DV.2.1
Endurance test for simultaneously energized controllers

Make amperes	Break amperes	Power factor		Number of test operations	Operation rate, seconds	
		Make	Break		On	Off
FLA ^a	LRA ^a	0,75 – 0,80	0,4 – 0,5	30 000	1	9
^a Rating of the winding controlled.						

Table 8.2.4.2DV.2.2
Endurance test for second controller delayed applications

Make amperes	Break amperes	Power factor		Number of test operations	Operation rate, seconds	
		Make	Break		On	Off
LRA ^a	LRA ^a	0,4 – 0,5	0,4 – 0,5	30 000	1	9
^a Rating of winding controlled.						

8.2.4.3 Durability

Subclause 7.2.4.3 of IEC 60947-1 applies with the following additions.

8.2.4.3.1 Mechanical durability

The mechanical durability of a contactor or starter is verified by a special test conducted at the discretion of the manufacturer. Recommendations for conducting this test are given in Annex B.

8.2.4.3.2 Electrical durability

Electrical durability of a contactor or starter is verified by a special test conducted at the discretion of the manufacturer. Recommendations for conducting this test are given in Annex B.

8.2.4.4 Overload current withstand capability of contactors

Contactors with utilization categories AC-3 or AC-4 shall withstand the overload currents given in Table 11, as specified in 9.3.5.

Table 11
Overload current withstand requirements

Rated operational current	Test current	Duration of test
≤630 A	$8 \times I_e \text{ max/AC-3}$	10 s
>630 A	$6 \times I_e \text{ max/AC-3}^*$	10 s
* With a minimum value of 5 040 A.		

NOTE This test also covers duties where the current is less than shown in Table 11 and the test duration is longer than 10 s, provided that the tested value of I^2t is not exceeded.

8.2.4.5 Coil power consumption

Where the power consumption of the coil is given, it shall be tested according to 9.3.3.2.1.2.

8.2.4.6 Pole impedance

Where the pole impedance is given, it shall be tested according to 9.3.3.2.1.3.

8.2.5 Co-ordination with short-circuit protective devices

8.2.5.1 Performance under short-circuit conditions (rated conditional short-circuit current)

The rated conditional short-circuit current of contactors and starters backed up by short-circuit protective device(s) (SCPD(s)), combination starters, combination switching devices, protected starters and protected switching devices shall be verified by short-circuit tests as specified in 9.3.4. These tests are mandatory:

- at the appropriate value of prospective current shown in Table 13 (test current " I_r "), and
- at the rated conditional short-circuit current I_{cs} , if higher than test current " I_r ".

The rating of the SCPD shall be adequate for any given rated operational current, rated operational voltage and the corresponding utilization category.

Two types of co-ordination are permissible, "1" or "2". The test conditions for both are given in 9.3.4.2.1 and 9.3.4.2.2.

Type "1" co-ordination requires that, under short-circuit conditions, the contactor or starter shall cause no danger to persons or installation and may not be suitable for further service without repair and replacement of parts.

Type "2" co-ordination requires that, under short-circuit conditions, the contactor or starter shall cause no danger to persons or installation and shall be suitable for further use. The risk of contact welding is recognized, in which case the manufacturer shall indicate the measures to be taken as regards the maintenance of the equipment.

NOTE Use of an SCPD not in compliance with the manufacturer's recommendations may invalidate the coordination.

These tests are applicable to AC motor ratings only.

8.2.5.1DV D2 Modification of 8.2.5.1 by adding the following:

8.2.5.1DV.1 The value of prospective test current " r " shall be selected from Table 17 or Table 53.3 of UL 508 or Table 24 of CSA C22.2 No. 14 at the discretion of the manufacturer.

8.2.5.1DV.2 Short circuit tests on a motor control device marked for use only with specific overload relays shall be performed with the motor control device installed as part of a starter. A marking shall be provided as specified in [6.2DV.2.4](#).

Note 2DV: In North America I_q is referred to as high available fault current and " r " is referred to as standard available fault current.

8.2.5.2 Co-ordination at the crossover current between starter and associated SCPD

Co-ordination at the crossover current between the starter and the SCPD is a special test. The way to verify it is described in [B.4](#).

8.3 Electromagnetic compatibility (EMC)

8.3DV D2 Modification of 8.3 and all subclauses by adding the following:

Clause [8.3](#) and all subclauses are informative.

8.3.1 General

Subclause 7.3.1 of IEC 60947-1 applies with the following addition.

Power frequency magnetic field tests are not required because the devices are naturally submitted to such fields. Immunity is demonstrated by the successful completion of the operational performance capability tests (see [9.3.3.5](#) and [9.3.3.6](#)).

This equipment is inherently sensitive to voltage dips and short time interruptions on the control supply; it shall react within the limits of [8.2.1.2](#) and this is verified by the operating limits tests given in [9.3.3.2](#).

8.3.2 Immunity

8.3.2.1 Equipment not incorporating electronic circuits

Subclause 7.3.2.1 of IEC 60947-1 applies.

8.3.2.2 Equipment incorporating electronic circuits

Subclause 7.3.2.2 of IEC 60947-1 applies with the following addition.

The test results are specified using the performance criteria given in [Table 12](#).

Table 12
Specific acceptance criteria for immunity tests

Item	Acceptance criteria		
	A	B	C
General	Normal performance within the specified limits	Temporary degradation or loss of function or performance which is self-recoverable	Temporary degradation or loss of function or performance which requires operator's intervention or system reset. There shall not be any damaged component
Operation of power and control circuits	No unwanted operation – the contactor shall remain in the expected position – the overload relay shall not trip	Temporary unwanted operation which cannot cause tripping Unintentional opening or closing of contacts is not accepted Self-recoverable	Tripping of overload relay Unintentional opening or closing of contacts Not self-recoverable
Operation of displays and auxiliary circuits	No changes to visible display information Only slight light intensity fluctuations of LEDs or movement of characters No unwanted operation of auxiliary contacts	Temporary visible changes, for example unwanted LED illumination Unintentional opening or closing of auxiliary contacts is not accepted.	Permanent loss of display information Unintentional opening or closing of auxiliary contacts is not accepted.
Information processing and sensing functions	Communication and data interchange to external devices without unwanted action or erroneous information	Temporarily disturbed communication with possible external impacts, but self-recoverable	Erroneous processing of information Loss of data and/or information Not self-recoverable

8.3.3 Emission

The level of severity required for environment B covers those required for environment A.

The devices covered by this standard do not generate significant levels of harmonics and therefore no harmonic tests are required.

8.3.3.1 Equipment not incorporating electronic circuits

Subclause 7.3.3.1 of IEC 60947-1 applies with the following addition.

Equipment incorporating only components such as diodes, varistors, resistors or capacitors is not required to be tested (e.g. in surge suppressors).

8.3.3.2 Equipment incorporating electronic circuits

Subclause 7.3.3.2 of part 1 applies.

9 Tests

9.1 Kinds of test

9.1.1 General

Subclause 8.1.1 of IEC 60947-1 applies.

9.1.2 Type tests

Type tests are intended to verify compliance of the design of contactors and starters of all types with this standard. They comprise the verification of:

- a) temperature rise limits (see [9.3.3.3](#));
- b) dielectric properties (see [9.3.3.4](#));
- c) rated making and breaking capacities (see [9.3.3.5](#));
- d) change-over ability and reversibility, where applicable (see [9.3.3.5](#));
- e) conventional operational performance (see [9.3.3.6](#));
- f) operation and operating limits (see [9.3.3.1](#) and [9.3.3.2](#));
- g) ability of contactors to withstand overload current (see [9.3.5](#));
- h) performance under short-circuit conditions (see [9.3.4](#));
- i) mechanical properties of terminals (see 8.2.4 of IEC 60947-1);
- j) degrees of protection of enclosed contactors and starters (see Annex C of IEC 60947-1);
- k) EMC tests, where applicable (see [9.4](#)).

9.1.3 Routine tests

Subclause 8.1.3 of IEC 60947-1 applies where sampling tests (see [9.1.4](#)) are not made.

Routine tests for contactors and starters comprise:

- operation and operating limits (see [9.3.6.2](#));
- dielectric tests (see [9.3.6.3](#)).

9.1.3DV D2 Modification of 9.1.3 by adding the following:

Clause [9.1.3](#) is informative.

9.1.4 Sampling tests

Sampling tests for contactors and starters comprise:

- operation and operating limits (see [9.3.6.2](#))
- dielectric tests (see [9.3.6.3](#)).

Subclause 8.1.4 of IEC 60947-1 applies with the following additions.

A manufacturer may use sampling tests instead of routine tests at his own discretion. Sampling shall meet or exceed the following requirements as specified in IEC 60410 (see Table II-A: Single sampling plans for normal inspection):

- sampling based on $AQL \leq 1$;
- acceptance number $A_c = 0$ (no defect accepted);
- rejection number $R_e = 1$ (if 1 defect, the entire lot shall be tested).

Sampling shall be made at regular intervals for each specific lot.

Alternative statistical methods that ensure compliance with the above IEC 60410 requirements can be used, e.g. statistical methods controlling continuous manufacturing or process control with capability index.

Sampling tests for clearance verification shall be performed according to 8.3.3.4.3 of IEC 60947-1.

9.1.4DV D2 Modification of 9.1.4 by adding the following:

Clause [9.1.4](#) is informative.

9.1.5 Special tests**9.1.5.1 General**

Special tests are mechanical and electrical durability tests and verification of co-ordination at the crossover current between the starter and the SCPD (see Annex [B](#)). The test results can be used to obtain data needed for functional safety applications (see Annex [K](#)).

9.1.5.2 Special tests – damp heat, salt mist, vibration and shock

For these special tests, Annex Q of IEC 60947-1 applies with the following additions.

Where Table Q.1 of IEC 60947-1 calls for verification of operational capability, this shall be done according to [9.3.6.2](#) of this standard.

The vibration tests shall be done on the equipment in the open and closed positions. The overload relay shall not trip during the test. To check the behavior of main and auxiliary contacts, tests can be done under any current /voltage value.

The shock test on the equipment shall be done in the open position.

For the dry heat test, the equipment shall be in the close position during the conditioning period (see 5.3.3 of IEC 60068-2-2). For categories A, B and C, the test may be done without current in the poles and for categories D, E and F, the test shall be done under the maximum rated AC-3 current, but may be limited to 100 A for practical reasons. During the last hour, the contactor shall be operated 5 times. During the whole test the overload relay may trip.

For the low temperature test, the test Ad is to be chosen instead of the test Ab and the equipment shall be in the open position during the cooling period. It shall then be energized for the last hour. For categories A, B and C, the test may be done without current in the poles and for categories D, E and F, the test is done under the maximum rated AC-3 current which may be limited to 100 A for practical reasons. During this last hour the contactor shall be operated 5 times. During the whole test the overload relay shall not trip.

For the damp heat test, for categories A, B and C, the test may be done without current in the poles. For categories D, E and F the equipment shall be energized under the maximum rated AC-3 current for the first cycle and de-energized for the second cycle. The current may be limited to 100 A for practical reasons. After stabilization of the temperature, during the first 2 h of the first cycle and during the last 2 h of the second cycle, the contactor shall be operated 5 times. The overload relay may trip only if it is permitted according to its temperature characteristic.

With the agreement of the manufacturer, the duration of the recovery periods may be reduced.

After the salt mist test, the product may be washed where agreed by the manufacturer.

9.2 Compliance with constructional requirements

9.2.1 General

Subclause 8.2 of IEC 60947-1:2007 applies with the following additions:

9.2.2 Electrical performance of screwless-type clamping units

Subclause 8.2.4.7 of IEC 60947-1:2007, Amendment 1 applies with the following changes:

The number of specimens shall be at least 4.

The insertion and disconnection of the conductors shall be made in accordance with the manufacturer's instructions.

A suitable test arrangement is shown in [Figure 10](#). If the measurement points cannot be positioned within the 10 mm to the point of contact, the voltage difference between the ideal and the actual measuring points shall be deducted from the voltage drop measured. This voltage difference within the part of the conductor shall be determined with a suitable measurement method on one specimen at a stabilised temperature. The measurement methods and the results shall be documented in the test report. The test current is I_{th} .

NOTE 1 Usually it is possible to equip a IEC 60947-4-1 product with many different types of wires (stranded, solid, flexible...) which results in a sufficient number of tests for the same terminal.

NOTE 2 Particular testing method with conductor cross sections larger than 10 mm² is under consideration.

NOTE 3 The device sample may be provided with holes or equivalent arrangements which provide measurement access points for the voltage drop on the terminal.

9.2.3 Ageing test for screwless-type clamping units

Subclause 8.2.4.8 of IEC 60947-1:2007, Amendment 1 applies with the following change:

The test shall be done on the device equipped with the clamping units.

The test current is I_{th} .

NOTE The device sample may be provided with holes or equivalent arrangements which provide measurement access points for the voltage drop on the terminal.

9.2DV D2 Modification of 9.2 by replacing 9.2.1 through 9.2.3 with the following:

Requirements for screwless terminals are defined in CSA C22.2 No. 158, CAN/CSA-C22.2 No. 60947-7-1, UL 1059, and UL 60947-7-1.

9.3 Compliance with performance requirements

9.3.1 Test sequences

Each test sequence is made on a new sample.

NOTE 1 With the agreement of the manufacturer, more than one test sequence or all test sequences may be conducted on one sample. However, the tests are conducted in the sequence given for each sample.

NOTE 2 Some tests are included in the sequences solely to reduce the number of samples required, the results have no significance for the preceding or following tests in the sequence. Therefore, for convenience of testing and by agreement with the manufacturer, these tests may be conducted on separate new samples and omitted from the relevant sequence. This only applies to the following tests when called for:

Subclause 8.3.3.4.1, item 7) of IEC 60947-1 : Verification of creepage distances.

Subclause 8.2.4 of IEC 60947-1: Mechanical properties of terminals.

Annex C of IEC 60947-1 : Degrees of protection of enclosed equipment.

The test sequence shall be as follows.

a) Test sequence 1

- 1) verification of temperature rise (see [9.3.3.3](#))
- 2) verification of operation and operating limits (see [9.3.3.1](#) and [9.3.3.2](#))
- 3) verification of dielectric properties (see [9.3.3.4](#))

b) Test sequence 2

- 1) verification of rated making and breaking capacities, change-over ability and reversibility, where applicable (see [9.3.3.5](#))

2) verification of conventional operational performance (see [9.3.3.6](#))

c) Test sequence 3

performance under short-circuit conditions (see [9.3.4](#));

d) Test sequence 4 (applicable to contactors only)

verification of ability to withstand overload currents (see [9.3.5](#));

e) Test sequence 5

1) verification of mechanical properties of terminals (see 8.2.4 of IEC 60947-1:2007, 9.2.1 and 9.2.2);

2) verification of degrees of protection of enclosed contactors and starters (see Annex C of IEC 60947-1).

There shall be no failure in any of the tests.

9.3.1DV D2 Modification of 9.3.1 by adding the following:

9.3.1DV.1 The sequence of tests for contactors and motor starters shall be as follows:

- a) Test sequence 1 shall apply. The calibration test for overload relays may be performed as a separate test sequence.
- b) Test sequence 2 shall apply with the addition of the dielectric withstand test in [9.3.3.4](#).
- c) Test sequence 4 is optional.
- d) Test sequence 5(1) shall be replaced by 8.2.4DV of CSA C22.2 No. 60947-1 and UL 60947-1.
- e) Test sequence 5(2) shall be replaced by 7.1.12DV of CSA C22.2 No. 60947-1 and UL 60947-1.

9.3.1DV.2 Sequence of tests for autotransformer starters, and resistance starters – For autotransformer starters or resistance starters, the duty cycle test (see [9.3.3.6DV.6.2](#)) and operation test (see [9.3.3.6DV.6.1](#)) shall apply.

9.3.1DV.3 Sequence of tests for electronic overload relays – Test sequences 1 and 3 shall apply. In the United States, the breakdown of components test per Clause 7.2.9DV.1 of CSA C22.2 No. 60947-1/UL 60947-1 shall apply as an individual test.

9.3.2 General test conditions

Subclause 8.3.2 of IEC 60947-1 applies with the following addition.

The selection of samples to be tested for a series of devices with same fundamental design and without significant difference in construction shall be based on engineering judgement.

Except for devices specifically rated for only one frequency, tests performed at 50 Hz are deemed to cover 60 Hz applications and vice-versa.

Unless otherwise specified in the relevant test subclause, the clamping torque for connections shall be that specified by the manufacturer or, if not specified, the torque given in Table 4 of IEC 60947-1.

9.3.3 Performance under no load, normal load and overload conditions

9.3.3.1 Operation

It shall be verified that contactors and starters operate according to the requirements of [8.2.1.1.2](#).

To verify the insensitivity of the starter to contactor operation, the starter shall be loaded to attain a steady state temperature as stated in [8.2.2](#) and the contactor operated in the normal switching sequence three times without intentional delay between operations. The starter shall not trip due to the contactor operation.

When the overload relay has a combined stop and reset actuating mechanism, with the contactor closed, the resetting mechanism shall be operated and this shall cause the contactor to drop out. When the overload relay has either a reset only or separate stop and reset actuating mechanisms, with the contactor closed and the resetting mechanism in the reset position, the tripping mechanism shall be operated and the contactor shall have been caused to drop out. These tests are to verify that the overload tripping action cannot be defeated by holding the resetting mechanism in the reset position.

In the case of rheostatic rotor starters, tests shall be performed to verify that the time setting of time-delay relays and the calibration of any other devices used for controlling the rate of starting are within the limits stated by the manufacturer.

The value of the starting resistors shall be verified for each section to be within $\pm 10\%$ of the stated figures.

It shall also be verified that the rotor switching devices cut out the steps of resistors in the correct sequence.

It shall also be verified that the open-circuit voltages on the tapping terminals of the auto-transformer are in accordance with the designed figures and that the phase sequence at the motor terminals of the two-step auto-transformer starter is correct in both the starting and ON positions of the starter.

9.3.3.2 Operating limits

9.3.3.2.1 Power-operated equipment

9.3.3.2.1.1 General

Contactors and starters shall be tested to verify their performance according to the requirements given in [8.2.1.2](#).

The drop out test requirements of 8.3.3.2.1 of IEC 60947-1:2007, Amendment 1 applies.

9.3.3.2.1.2 Coil power consumption

9.3.3.2.1.2.1 General

A contactor coil is evaluated for both holding power and pick-up power.

In the case where different coils cover a range of voltages, 5 coils shall be tested as follows:

The coil with the lowest rated control supply voltage U_s , the coil with the highest rated control supply voltage U_s , plus 3 coils deemed to be representative of the coils with the highest calculated hold power at the discretion of the manufacturer.

The test shall be performed at ambient temperature $+23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$. The test shall be made without any load in the main and auxiliary circuits. The coil shall be supplied with the rated control supply voltage U_s and at the rated frequency. For a given coil, where a voltage range is declared, the test shall be made at the highest voltage at the respective frequency.

The measured values shall be obtained with a r.m.s. measurement method covering at least a bandwidth from 0 Hz to 10 kHz and the resulting power values shall be given within a measurement uncertainty better than 5 %.

9.3.3.2.1.2.2 Holding power for conventional and electronically controlled electromagnet

The current measurement $I_{(i)}$ of the coil shall be performed after the coil has been energized and has reached a stable temperature.

The holding power consumption is defined as follows:

$$S_{h(i)} = U_{s(i)} \times I_{(i)} \text{ [VA] for a.c. controlled contactor;}$$

$$P_{c(i)} = U_{s(i)} \times I_{(i)} \text{ [W] for d.c. controlled contactor.}$$

The published value shall be equal to the average value of the 5 tested coils.

$$S_h = \Sigma (U_{s(i)} \times I_{(i)}) / 5 \text{ [VA] respectively } P_c = \Sigma (U_{s(i)} \times I_{(i)}) / 5 \text{ [W]}$$

NOTE The power dissipation for an a.c. controlled contactor can also be expressed in [W], taking into account the power factor.

9.3.3.2.1.2.3 Pick-up power for a.c. controlled contactor or d.c. controlled contactor with separate pick-up and hold-on windings

The pick-up measurement shall be performed directly after the measurement of the hold current (see [9.3.3.2.1.2.2](#)).

The current measurement $I_{(i)}$ of the coil shall be performed immediately after the coil has been de-energized, the contactor has been held in the Off position and re-energized.

The pick-up power consumption is defined as follows:

$$S_{p(i)} = U_s \times I_{(i)} \text{ [VA] for a.c. controlled contactor;}$$

$$P_{p(i)} = U_s \times I_{(i)} \text{ [W] for d.c. controlled contactor with separate pick-up and hold windings.}$$

The published value shall be equal to the average value of the 5 tested coils.

$$S_p = \Sigma (U_{s(i)} \times I_{(i)}) / 5 \text{ [VA] respectively } P_p = \Sigma (U_{s(i)} \times I_{(i)}) / 5 \text{ [W]}$$

NOTE Unless otherwise stated in the manufacturer literature, for d.c. conventional controlled contactor, the pickup power is equal to the holding power.

9.3.3.2.1.2.4 Pick-up power for electronically controlled electromagnet

Under consideration.

9.3.3.2.1.3 Pole impedance

The pole impedance shall be determined during the test and with the conditions given in [9.3.3.3.4](#). The test in an enclosure is not deemed necessary even if the contactor can be used in an individual enclosure.

The voltage drop U_d shall be measured between the line and load terminals (terminals included) of the contactor preferably at the same time the temperature rise is measured.

The impedance per pole is defined as follows:

$$Z = U_d / I_{th} [\Omega]$$

Care should be taken that voltage drop measurement does not significantly affect the temperature rise nor affect significantly the impedance.

NOTE The method is the same irrespective of the number of poles of the contactor.

9.3.3.2.1DV D2 Modification of 9.3.3.2.1 and all subclauses by adding the following:

[9.3.3.2.1](#) and all subclauses are informative.

9.3.3.2.2 Relays and releases

a) Operation of under-voltage relays and releases

Under-voltage relays or releases shall be tested for compliance with the requirements of [8.2.1.3](#). When associated with a switching device, the release shall be fitted to the switching device having the maximum current rating for which the release is suitable.

1) Drop-out voltage

The voltage shall be reduced from rated control supply voltage at a rate to reach 0 V in approximately 30 s.

The test for the lower limit is made without previous heating of the release coil. In the case of a release with a range of rated control supply voltage, this test applies to the maximum voltage of the range. When associated with a switching device, the test for the lower limit is made without current in the main circuit.

The test for the upper limit is made starting from a constant temperature corresponding to the application of rated control supply voltage to the release and rated current in the main poles. This test may be combined with the temperature-rise test of [9.3.3.3](#). In the case of a release with a range of rated control supply voltage, this test is made at the minimum rated control supply voltage.

2) Test for limits of operation when associated with a switching device

Starting with the main circuit open, at the temperature of the test room, and with the supply voltage at 35 % rated maximum control supply voltage, it shall be verified that the switching device cannot be closed by the operation of its actuator. When the supply voltage is raised to 85 % of the

minimum control supply voltage, it shall be verified that the switching device can be closed by the operation of its actuator.

3) Performance under over-voltage conditions

When associated with a switching device, the test is made without current in the main circuit. The test at 110 % of the rated supply voltage shall be made for 30 min or until the temperature has reached thermal equilibrium and without impairing its functions. Verification shall be made according 2) above.

b) Shunt-coil operated releases

Shunt releases shall be tested for compliance with the requirements of [8.2.1.4](#) at the ambient temperature. When associated with a switching device, the release shall be fitted to the switching device having the maximum rated current for which the release is suitable.

In the case of a release having a range of rated control supply voltages, the test voltages shall be 70 % of the minimum rated control supply voltage and 110 % of the maximum rated control voltage.

c) Thermal, electronic and time-delay magnetic overload relays

Overload relays and starters shall be connected using conductors in accordance with Table 9, Table 10 and Table 11 of IEC 60947-1 for test currents corresponding to:

- 100 % of the current setting of the overload relay for overload relays of trip classes 2, 3, 5 and 10 A for all overload relay types (see [Table 2](#)) and 10, 20, 30 and 40 for electronic overload relay types;
- 125 % of the current setting of the overload relay for thermal overload relays of trip classes 10, 20, 30 and 40 (see [Table 2](#)) and for overload relays for which a maximum tripping time greater than 40 s is specified (see [5.7.3](#)).

It shall be verified that relays and releases operate according to the requirements of [8.2.1.5.1](#) with all poles energized.

The characteristics defined in [8.2.1.5.1](#) shall be verified at –5 °C, +20 °C, +40 °C. In addition any declared time-current characteristics outside the –5 °C, +40 °C range shall be verified at minimum and maximum temperatures. However, for relays or releases declared compensated for ambient temperature, in case of temperature range declared by the manufacturer is outside the range given in [Table 3](#), the characteristics at –5 °C and/or +40 °C need not be verified if, when tested at the declared minimum and maximum temperatures, the corresponding tripping current values are in compliance with the limits specified for –5 °C and/or +40 °C in that [Table 3](#).

For electronic overload relays, the thermal memory test verification of [8.2.1.5.1.2](#) shall be carried out at +20 °C.

Three-pole thermal or electronic overload relays energized on two poles only shall be tested as stated in [8.2.1.5.2](#) on all combinations of poles and at the maximum and minimum current settings for relays with adjustable settings.

d) Instantaneous magnetic overload relays

Each relay shall be tested separately. The current through the relay shall be increased at a rate suitable for an accurate reading to be made. The values shall be as stated in [8.2.1.5.3](#).

e) Under-current relays

The limits of operation shall be verified in accordance with [8.2.1.5.4.1](#).

f) Under-current relays in automatic change-over

The limits of operation shall be verified in accordance with [8.2.1.5.4.2](#).

g) Stall relays

The limits of operation shall be verified in accordance with [8.2.1.5.5](#).

For current sensing stall relays, the verification shall be made for the minimum and for the maximum set current values and for the minimum and maximum stall inhibit time (four settings).

For stall relays operating in conjunction with a rotation sensing mean, the verification shall be made for the minimum and maximum stall inhibit time. The sensor can be simulated by an appropriate signal on the sensor input of the stall relay.

h) Jam relays

The limits of operation shall be verified in accordance with [8.2.1.5.6](#).

The verification shall be made for the minimum and for the maximum set current values and for the minimum and maximum jam inhibit time (four settings).

For each of the four settings, the test shall be made under the following conditions:

- apply a test current of 95 % of the set current value. The jam relay shall not trip;
- increase the test current to 120 % of the set current value. The jam relay shall trip according to the requirements given in [8.2.1.5.6](#).

9.3.3.3 Temperature rise

9.3.3.3.1 Ambient air temperature

Subclause 8.3.3.3.1 of IEC 60947-1 applies.

9.3.3.3.2 Measurement of the temperature of parts

Subclause 8.3.3.3.2 of IEC 60947-1 applies.

9.3.3.3.3 Temperature rise of a part

Subclause 8.3.3.3.3 of IEC 60947-1 applies.

9.3.3.3.4 Temperature rise of the main circuit

Subclause 8.3.3.3.4 of IEC 60947-1 applies with the following additions. The main circuit shall be loaded as stated in [8.2.2.4](#).

All auxiliary circuits which normally carry current shall be loaded at their maximum rated operational current (see [5.6](#)) and the control circuits shall be energized at their rated voltages.

The starter shall be fitted with an overload relay complying with [5.7.4](#) and selected as follows:

– Non-adjustable relay

The current setting shall be equal to the maximum operational current of the starter and the test shall be made at this current;

– Adjustable relay

The maximum current setting shall be that which is nearest to but not greater than the maximum operational current of the starter.

The test shall be made with that overload relay for which the current setting is nearest to the maximum of its scale.

NOTE 1 The selection method described above is designed to ensure that the temperature rise of the field wiring terminals of the overload relay and the power dissipated by the starter are not less than those that will occur under any combination of relay and contactor. In cases where the effect of the overload relay on these values is insignificant (i.e. electronic overload relays), the test current shall always be the maximum operational current of the starter.

For equipment intended for utilization category AC-6b, the test current for the temperature rise test shall be equal to 1,35 times I_e (the rated capacitive current). I_e shall be calculated as follow:

– $I_e = Q \text{ (var)} / U_e$ for single-phase rating, where U_e is the minimum rated voltage;

– $I_e = Q \text{ (var)} / (U_e \times \sqrt{3})$ for three-phases rating, where U_e is the minimum rated voltage.

NOTE 2 This calculation follows the requirements of IEC 60381-1.

The test shall be done with cross section of conductor based on 1,35 times I_e (the rated capacitive current).

9.3.3.3.5 Temperature rise of control circuits

Subclause 8.3.3.3.5 of IEC 60947-1 applies with the following addition.

The temperature rise shall be measured during the test of [9.3.3.3.4](#).

9.3.3.3.6 Temperature rise of coils and electromagnets

Subclause 8.3.3.3.6 of IEC 60947-1 applies with the following additions.

The coil with the highest power consumption, for a given frequency a.c. or d.c., according to [9.3.3.2.1.2.2](#) is deemed to be representative for all coils, for the same contactor, and shall be used for the temperature rise test.

a) Electromagnets of contactors or starters intended for uninterrupted or 8 h duty are subjected only to the conditions prescribed in [8.2.2.7.1](#), with the corresponding rated current flowing through the main circuit for the duration of the test. The temperature rise shall be measured during the test of [9.3.3.3.4](#).

b) Electromagnets of contactors or starters intended for intermittent duty shall be subjected to the test as stated above, and also to the test prescribed in [8.2.2.7.2](#) dealing with their duty class, with no current flowing through the main circuit.

c) Specially rated (temporary and periodic duty) windings shall be tested as stated in [8.2.2.7.3](#), without the current in the main circuit.

9.3.3.3.7 Temperature rise of auxiliary circuits

Subclause 8.3.3.3.7 of IEC 60947-1 applies with the following addition.

The temperature rise shall be measured during the test of [9.3.3.3.4](#).

9.3.3.3.8 Temperature rise of starting resistors for rheostatic rotor starters

The temperature rise of resistors shall not exceed the limits specified in Table 3 of IEC 60947-1, when the starter is operated at its rated duty (see [5.3.4](#)) and according to its starting characteristics (see [5.3.5.5.1](#)).

The current through each section of the resistors shall be thermally equivalent to the current during the starting time when the controlled motor is operating with the maximum starting torque and the starting time for which the starter is rated (see [5.3.4](#) and [5.3.5.5.1](#)); in practice, the current value I_m can be used.

Starting operations shall be evenly spaced in time according to the number of starts per hour.

The temperature rise of the enclosures and of the issuing air shall not exceed the limits specified in Table 3 of IEC 60947-1.

NOTE It is not practical to test the performance of starting resistors of every combination of motor output and rotor voltage and current; it is recommended only that a sufficient number of tests be made to prove, by interpolation or deduction, compliance with this standard.

9.3.3.3.8DV D2 Modification of 9.3.3.3.8 by adding the following:

The temperature rises specified in Table 3 of IEC 60947-1 do not apply. Temperature rises shall not exceed those specified in Table 27DV of CSA C22.2 No. 60947-1/UL 60947-1. The resistor shall not burn out during the test.

9.3.3.3.9 Temperature rise of the auto-transformer for two-step auto-transformer starters

The temperature rise of the auto-transformer shall not exceed the limits specified in [Table 5](#) increased by 15 K (see [8.2.2](#)) and those specified in Table 3 of IEC 60947-1:2007, when the starter is operated at its rated duty (see [5.3.4](#)).

The current through each winding of the auto-transformer shall be thermally equivalent to the current carried when the controlled motor is operating with the maximum starting current and starting time for which the starter is rated (see [5.3.5.5.3](#)); this condition is assumed to be reached when the current drawn from the auto-transformer during the starting time is equal to the maximum starting current specified in [5.3.5.5.3](#) multiplied by:

$$0,8 \times \frac{\text{starting voltage}}{U_e} \text{ (see 5.3.1.4)}$$

The operating cycles shall be evenly spaced in time according to the number of starts per hour (see [5.3.4.3](#)).

In the event of two successive operating cycles (see [5.3.4.3](#)), the temperature rise of the auto-transformer may exceed the maximum value given in [8.2.2](#) but no damage shall result to the auto-transformer.

In the case of an auto-transformer with several sets of taps, the test shall be made with the taps giving the highest power loss in the transformer; it shall be made over a period of time sufficient for the temperature rise to reach a constant value.

In order to facilitate this test, star-connected impedances may be used in place of a motor.

9.3.3.3.9DV D2 Modification of 9.3.3.3.9 by replacing the first paragraph with the following:

Temperature rises shall not exceed the temperature rises specified in Table 27DV of CSA C22.2 No. 60947-1/UL 60947-1.

9.3.3.4 Dielectric properties

Subclause 8.3.3.4 of IEC 60947-1 applies with the following modifications.

9.3.3.4.1 Type tests

Subclause 8.3.3.4.1 of IEC 60947-1 applies with the addition of

- the following sentences, at the end of item 1):

The metal foil shall be applied to all surfaces where these are likely to be touched by people during normal operation or adjustment of the equipment and where such surfaces can also be touched by the standard test finger.

The metal foil shall not be applied for power frequency withstand verification after switching and short-circuit tests.

- the following sentence, after the second paragraph of item 2) b):

Circuits of a contactor or starter including devices which have been subjected to U_{imp} test voltages lower than those specified in 7.2.3.1 of IEC 60947-1 and 8.3.3.4.2 of IEC 60947-1 may be disconnected for the test, according to the manufacturer's instructions.

- the following sentence, after the paragraph of item 2) c) ii):

Where the control circuit normally connected to the main circuit is disconnected (according to 8.3.3.4.1 of IEC 60947-1, item 2) b)), the method used to maintain the main contacts closed shall be indicated in the test report.

- the following sentence at the end of 8.3.3.4.1 of IEC 60947-1, item 8):

For equipment suitable for isolation, the leakage current shall be measured through each pole with the contacts in the open position, at a test voltage of $1,1 U_e$ and shall not exceed 0,5 mA.

Verification of impulse withstand voltage across open contacts is not required for equipment not suitable for isolation (see 8.3.3.4.1, item 2) c) iv) of IEC 60947-1).

9.3.3.5 Making and breaking capacities

Subclause 8.3.3.5 of IEC 60947-1 applies with the following additions.

9.3.3.5.1 General test conditions

The tests shall be made, under the operating conditions stated in [Table 7](#), without failure, see [9.3.3.5.5 f\)](#).

The control supply voltage shall be 100 % of U_s , except that, for the make only test of utilization categories AC-3 and AC-4, the control supply voltage shall be 110 % of U_s for half the number of operating cycles and 85 % of U_s for the other half.

NOTE If there is no distinction between U_s and U_c , then the test has to be done with U_c accordingly.

Connections to the main circuit shall be similar to those intended to be used when the contactor or starter is in service. If necessary, or for convenience, the control and auxiliary circuits, and in particular the magnet coil of the contactor or starter, may be supplied by an independent source. Such a source shall deliver the same kind of current and the same voltage as specified for service conditions.

The overload relay and the SCPD of the starter may be short-circuited for the purpose of carrying out the rated making and breaking capacity tests.

9.3.3.5.2 Test circuit

Subclause 8.3.3.5.2 of IEC 60947-1 applies.

9.3.3.5.3 Characteristics of transient recovery voltage

Subclause 8.3.3.5.3 of IEC 60947-1 applies to utilization categories AC-2, AC-3, AC-4, AC-8a and AC-8b (see [Table 1](#)).

It is not necessary to adjust factor γ or the oscillatory frequency for testing making capacity only (in AC-3 and AC-4).

9.3.3.5.3DV D2 Modification of 9.3.3.5.3 by replacing it with the following:

Shunt resistors may be as provided in [9.3.3.5.5DV.5](#).

9.3.3.5.4 Void

9.3.3.5.5 Rated making and breaking capacities

If the contactor in a starter has separately satisfied the requirements of item a) hereafter for the utilization category of the starter, the starter need not be tested.

a) Rated making and breaking capacities of contactors

The contactor shall make and break the current corresponding to its utilization category and for the number of operating cycles given in [Table 7](#). See also item d) hereafter for reversing contactors.

Contactors of utilization categories AC-3 and AC-4 shall be subjected to 50 making only operations followed by 50 making and breaking operations.

b) Rated making and breaking capacity of direct-on-line and two direction starters (AC-3) and stator switching devices of rheostatic rotor starters (AC-2)

The starter shall make and break the current corresponding to its utilization category for the number of operating cycles given in [Table 7](#).

Starters of utilization category AC-3 shall be subjected to 50 making only operations followed by 50 making and breaking operations.

c) Rated making and breaking capacities and change-over ability of star-delta starters (AC-3) and two-step auto-transformer starters (AC-3)

The starter shall make and break the currents corresponding to its utilization category given in [Table 7](#).

Both the starting and the ON or delta position of the starters shall first be subjected to 50 making only operations, the current being broken by a separate switching device.

The starter shall then be subjected to the 50 making and breaking operations. Each operating cycle shall consist of the following sequences:

- make the current in the starting or star position;
- break the current in the starting or star position;
- make the current in the ON or delta position;
- break the current in the ON or delta position;
- off period.

The load circuit shall be connected to the starter as would be the windings of a motor. The rated operational current of the starter (I_e) is the current in the ON or delta position.

NOTE In the case of star-delta starters, it is important that the test currents be measured in star and delta since the supply impedance has a significant effect on the transformation ratio.

When a transformer has more than one output voltage, it shall be connected to give the highest starting voltage.

The on-time in the starting and ON positions and the off-time shall be as stated in [Table 7](#).

d) Rated making and breaking capacities of direct-on-line and reversing starters (AC-4)

The starters shall make and break the currents given in [Table 7](#).

The 50 making only operations shall be done first, the current being broken by a separate switching device, followed by the 50 making and breaking operations.

The load circuit shall be connected to the starter as would be the windings of a motor.

For starters incorporating two contactors, two contactors A and B shall be used and wired as in normal application. Each sequence of the 50 operations shall be:

close A – open A – close B –
open B – off period

The change-over from "open A" to "close B" shall be made as fast as the normal control system will allow.

Mechanical or electrical interlocking means provided in the starter or available for associating contactors as reversing devices shall be used.

If the reversing circuit arrangement is such that both contactors can be energized simultaneously, ten additional sequences shall be conducted with both contactors energized simultaneously.

e) Rated making and breaking capacities of the rotor switching devices of a rheostatic rotor starter

Verification of the making and breaking capacities of the rotor switching devices shall be performed as in [9.3.3.5.5](#) b) for AC-2 category where $I_e = I_{er}$, the maximum rated rotor current for which the starter is designed. $U_e = U_{er}$ (rated rotor operational voltage) and U/U_e shall be 0,8. The power factor shall be 0,95. The starting resistors may be disconnected for these tests and, for starters having more than two steps, the test shall be performed on each switching device in turn. Since the rotor switching devices in starters having more than two steps do not break and make at the full rotor voltage, the voltage for these tests may be reduced in the ratio:

$$\frac{\text{Starting resistance switched}}{\text{Total starting resistance}}$$

When a starter is so connected that the circuit is opened by the stator switch before the rotor switching devices open, no verification of the breaking capacity is necessary.

For rotor switching devices which have previously satisfied the requirements corresponding to those specified above, no further tests are needed.

f) Behaviour and condition of the contactor or starter during and after the making and breaking capacity, change-over and reversing tests

During the tests within the limits of the specified making and breaking capacities of [9.3.3.5](#) and the verification of conventional operational performance of [9.3.3.6.1](#) to [9.3.3.6.6](#), there shall be no permanent arcing, no flash-over between poles, no blowing of the fusible element in the earth circuit (see [9.3.3.5.2](#)) and no welding of the contacts.

The contacts shall operate when the contactor or starter is switched by the applicable method of control.

9.3.3.5.5DV D2 Modification of 9.3.3.5.5 by replacing it with 9.3.3.5.5DV.1 to 9.3.3.5.5DV.9 as follows:

9.3.3.5.5DV.1 The overload test or tests shall cover the conditions of maximum interrupted values of voltage, power, and current.

9.3.3.5DV.2 Tests on equipment having an alternating-current rating shall be conducted using a circuit having a frequency in the range of 25 – 60 hertz.

9.3.3.5DV.3 Equipment shall close and open a test circuit connected as shown in [Figure 9.3.3.5DV.3.1](#) and have the current and power factor as described in [Table 8.2.4.1DV.1.1](#) or [Table 7](#), as appropriate.

9.3.3.5DV.4 Air-core type reactors shall be used to obtain the reactive power factor specified in [Table 8.2.4.1DV.1.1](#). Reactors may be connected in parallel. No reactor shall be connected in parallel with a resistor.

9.3.3.5DV.5 An air-core reactor in any phase may be connected in parallel with a resistor (RSH) when the resistor power consumption is approximately 1 percent of the total power consumption in that phase calculated in accordance with the following formula:

$$R_{SH} = 100 \left(\frac{1}{PF} - PF \right) \frac{E}{I}$$

in which:

PF = power factor,

E = closed-circuit phase voltage, and

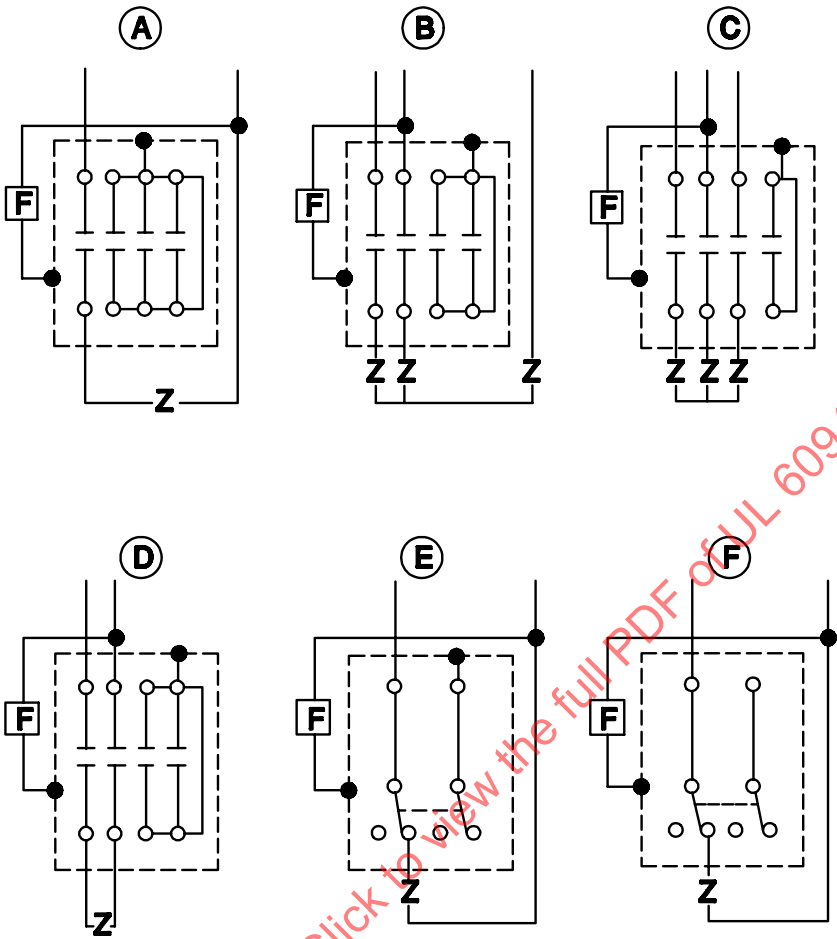
I = phase current.

Except as specified in [9.3.3.5DV.6](#), the closed test circuit voltage shall be 100 to 110 percent of the required test voltage specified in Table 28DV of CSA C22.2 No. 60947-1/UL 60947-1.

9.3.3.5DV.6 For a motor controller rated more than 18,6 kW output (25 horsepower) or a magnetically operated switch rated more than 100 amperes, the open-circuit voltage shall be as much above the voltage specified as the closed-circuit voltage is below that value, unless such adjustment results in the open-circuit voltage being more than 110 percent of the specified voltage. In that case, the test shall be conducted using whatever closed-circuit voltage is obtained when the open-circuit voltage is 110 percent of the specified voltage. However, the capacity of the supply circuit need not be greater than that of a circuit that is considered to be acceptable for the short-circuit test.

9.3.3.5DV.7 Tests on a reversing controller provided with a factory-installed mechanical, electrical, or electronic interlock, or any combination thereof, shall be conducted with all such interlocks in operation. When an interlock system is provided as an option, that system shall be defeated during the test.

Figure 9.3.3.5DV.3.1
Overload test connection diagrams (9.3.3.5DV.3)



F = FUSE

Z = IMPEDANCE

----- = ENCLOSURE

S3587

The enclosure shall be connected through a ground fuse, 30-ampere fast acting fuse, to the electrical test circuit pole least likely to strike to ground.

Diagrams A and B show connections for a device for single- and 3-phase loads, respectively, that are unmarked regarding load connection.

Diagram C and D show connections for a device for 3-phase and single-phase loads, respectively, that are marked "Break All Lines" or the equivalent.

Diagram E shows connections for a double-pole, double-throw relay that is unmarked for polarity connection.

Diagram F shows connections for a double-pole, double-throw relay marked for same polarity.

9.3.3.5DV.8 Test cycle requirements – For all equipment except a reversing controller, the test cycle time shall be 1 second on and 9 seconds off. For a reversing controller, the test cycle time shall be 1 second forward, 1 second reverse, and 8 seconds off.

a) When the device operation will not permit these cycle times, times as close as possible to these shall be used.

b) When it is determined that for a duration less than one second, the device conducts the test current without interrupting the circuit or being adversely affected by heat and the device contacts are properly seated before the break is initiated as confirmed by oscilloscopic or oscillographic measurements, the on time may be reduced to that duration.

c) The off time for equipment conducting a test current of 500 – 1 499 amperes shall be no more than 120 seconds, and for devices conducting a test current more than 1 499 amperes, the off time shall be no more than 240 seconds.

9.3.3.5DV.9 Overload test acceptance criteria – During the overload test, there shall be no electrical or mechanical breakdown of the equipment and no welding of the contacts. The ground fuse specified in the test procedure shall not open.

9.3.3.6 Operational performance capability

Subclause 8.3.3.6 of IEC 60947-1 applies with the following additions.

Tests concerning the verification of conventional operational performance are intended to verify that a contactor or starter is capable of fulfilling the requirements given in [Table 10](#).

Connections to the main circuit shall be similar to those intended to be used when the contactor or starter is in service.

The overload relay and the SCPD of the starter may be short-circuited for the purpose of carrying out the tests.

The test circuit given in [9.3.3.5.2](#) is applicable and the load is to be tuned according to [9.3.3.5.3](#).

The control voltage shall be 100 % of the rated control supply voltage.

If the contactor in a starter has separately satisfied the requirements of [9.3.3.6.1](#) for the utilization category of the starter, the starter need not be tested.

9.3.3.6DV D2 Modification of 9.3.3.6 by replacing it and all subclauses with 9.3.3.6DV.1 to 9.3.3.6DV.6 as follows:

9.3.3.6DV.1 Endurance test – The conditions for the endurance test shall be the same as the conditions for the overload test in [9.3.3.5DV](#), except as described in [9.3.3.6DV.2](#) to [9.3.3.6DV.5](#).

Table 9.3.3.6DV.1
Endurance test cycle for motor controllers

([Table 8.2.4.2DV.1.1](#))

Type of controller	Test current, amperes	Time on ^a seconds	Maximum time off, seconds
Nonreversing	Less than 200	0,5	0,5
	200 – 499	1	1
	500 – 1 499	1	120
	1 500 or more	1	240
Reversing	Less than 200	0,5 forward 0,5 reverse	1
	200 – 499	1 forward 1 reverse	2
	500 – 1 499	1 forward 1 reverse	120
	1 500 or more	1 forward 1 reverse	240

^a Or as noted in [9.3.3.5DV.8](#).

9.3.3.6DV.2 The equipment shall close and open a test circuit having the applicable current and power factor. The number of test cycles and the test cycle times shall be as specified in [Table 8.2.4.2DV.1.1](#) and [Table 10](#). The closed circuit test voltage shall be 100 to 110 percent of the required test voltage specified in Table 28DV of CSA C22.2 No. 60947-1/UL 60947-1.

9.3.3.6DV.3 Tungsten loads – When tungsten-filament lamps are used as the load, the load shall be made up of the smallest possible number of 500-watt lamps, or of larger lamps when agreeable to those concerned. One or two lamps smaller than the 500-watt size may be used when necessary to make up the required load.

The circuit shall be such that the peak value of the inrush current will be reached in 1/240 of a second after the circuit is closed.

9.3.3.6DV.4 Endurance test acceptance criteria – During the endurance test, there shall be no electrical or mechanical breakdown of the equipment, and no welding of the contacts. The ground fuse specified in the test procedure shall not open.

9.3.3.6DV.5 After the test, the device shall comply with the requirements of dielectric properties in [9.3.3.4](#).

9.3.3.6DV.6 Reduced voltage starters

9.3.3.6DV.6.1 Operation test

After 100 operations under the most severe normal conditions for which it is intended, a rheostat, an autotransformer, a speed regulator, or a similar device, or a starter containing such a device, shall show no serious burning of the contacts or other faults. The release mechanism of a motor-starting rheostat shall not be impaired by such a test.

9.3.3.6DV.6.2 Duty cycle test

9.3.3.6DV.6.2.1 An autotransformer, a reactor starter, or a motor starting resistor shall not show resultant flaming or molten droppings when the maximum rated voltage is applied to line terminals, and when tested as indicated in [Table 9.3.3.6DV.6.2.1.1](#) and [9.3.3.6DV.6.1](#). When the transformer windings are oil immersed, the oil shall not overflow its containing case.

9.3.3.6DV.6.2.2 The test may be terminated before the end of the period specified in [Table 9.3.3.6DV.6.2.1.1](#) when the autotransformer or resistor is protected for overheating by a reliably operating, nonadjustable thermostat or similar device.

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

Table 9.3.3.6DV.6.2.1.1
Duty cycle test for reduced voltage motor starting

([6.2DV.4](#), [9.3.3.6DV.6.2.1](#), [9.3.3.6DV.6.2.2](#))

Device characteristics			Load parameters ^a		Duty cycle		Test sequence		
Duty class	Motor rating	Auto-transformer tap or resistance step used	Current	Power factor	ON Time, Sec	OFF Time, Sec	Number of duty cycles	Rest Time, Hours	Number of duty cycles
Motor starting auto-transformer or reactor									
Heavy	All	Lowest	LRA	0,50	60	60	5	2	5
Medium	224 kW (300 hp) or less (Manual)	65 %	300 % FLA	0,50	15	225	4	2	4
Medium	149 kW (200 hp) or less (Magnetic)	65 %	300 % FLA	0,50	15	225	15	2	15
Medium	Over 149 kW (200 hp) (Magnetic)	65 %	300 % FLA	0,50	30	30	3	1	3
Motor starting resistor									
–	Direct current motor	First step ^b	FLA	1,0	180	–	1	–	–
–	Alternating current motor	Each step	300 % FLA	1,0	15	225	15	–	–

^a The test voltage shall be between 100 and 110 percent of maximum rated voltage and shall be applied across the entire device and the indicated tap or step of the starting mechanism.

^b When greater than rated motor current results, external resistance shall be added to reduce the current to rated value. When less than rated current results, the starting mechanism shall be adjusted to the subsequent step of resistance that results in not more than rated current, with or without added resistance.

9.3.3.6.1 Conventional operational performance of contactors

The contactor shall make and break the current corresponding to its utilization category and for the number of operating cycles given in [Table 10](#). See also [9.3.3.6.4](#).

9.3.3.6.2 Conventional operational performance of direct-on-line and two direction starters (AC-3) and stator switching devices of rheostatic rotor starters (AC-2)

The starter shall make and break the current corresponding to its utilization category and for the number of operating cycles given in [Table 10](#).

9.3.3.6.3 Conventional operational performance of star-delta starters (AC-3) and two-step auto-transformer starters (AC-3)

The starter shall make and break the current corresponding to its utilization category for the number of operating cycles given in [Table 10](#).

The test procedure shall be as stated in [9.3.3.5.5](#), item c), except that the 50 making only operations are not done.

9.3.3.6.4 Conventional operational performance of direct-on-line and reversing starters (AC-4)

The starter shall make and break the current corresponding to its utilization category for the number of operating cycles given in [Table 10](#).

The test procedure shall be as stated in [9.3.3.5.5](#), item d), except that the 50 making only operations and the 10 additional sequences of simultaneous energizing are not done.

9.3.3.6.5 Conventional operational performance of the rotor switching devices of a rheostatic rotor starter

Verification of conventional operational performance of the rotor switching devices shall be performed as in [9.3.3.6.1](#) for the AC-2 category given in [Table 10](#).

The test procedure shall be as stated in [9.3.3.5.5](#), item e).

9.3.3.6.6 Behaviour of the contactor or starter during, and its condition after, the conventional operational performance tests

The requirements of [9.3.3.5.5](#), item f), shall be fulfilled and then the verification of power frequency withstand according to [8.3.3.4.1](#), item 4), of IEC 60947-1 shall be made.

For equipment suitable for isolation, the leakage current shall be measured through each pole, with the contacts in the open position, at a test voltage of $1,1 U_e$ and shall not exceed 2 mA.

For equipment provided with mirror contacts, the additional test of [F.7.3](#) shall be carried out.

9.3.4 Performance under short-circuit conditions

This subclause specifies test conditions for verification of compliance with the requirements of [8.2.5.1](#). Specific requirements regarding test procedure, test sequences, condition of equipment after the test and types of co-ordination are given in [9.3.4.1](#) and [9.3.4.2](#).

9.3.4.1 General conditions for short-circuit tests

9.3.4.1.1 General requirements for short-circuit tests

Subclause 8.3.4.1.1 of IEC 60947-1 applies with the following modification.

If devices tested in free air may also be used in an individual enclosure, they shall be additionally tested in the smallest of such enclosures stated by the manufacturer. For devices tested only in free air, information shall be provided to indicate that the device has not been evaluated for use in an individual enclosure.

NOTE An individual enclosure is an enclosure designed and dimensioned to contain one device (starter, etc) only.

The individual enclosure shall be in accordance with the manufacturer specifications. In case of multiple enclosure options are provided, the individual enclosure with the smallest volume shall be taken.

Enclosed stationary and moveable assemblies are tested according to IEC 61439-1.

9.3.4.1.1DV D2 *Modification of 9.3.4.1.1 by adding the following:*

Open equipment shall be tested in an enclosure sized in accordance with 8.3.2.1DV.1.1 of CSA C22.2 No. 60947-1/UL 60947-1 and constructed in accordance with 7.1.12DV of CSA C22.2 No. 60947-1/UL 60947-1.

9.3.4.1.2 Test circuit for the verification of short-circuit ratings

Subclause 8.3.4.1.2 of IEC 60947-1 applies except that, for type "1" co-ordination, the fusible element F and the resistor R_L are replaced by a solid 6 mm² wire of 1,2 m to 1,8 m in length, connected to the neutral, or with the agreement of the manufacturer, to one of the phases.

NOTE This larger size of wire is not used as a detector but to establish an "earth" condition allowing the damage to be evaluated.

9.3.4.1.3 Power-factor of the test circuit

Subclause 8.3.4.1.3 of IEC 60947-1 applies.

If [Table 17](#) is used, the power factor is given in this [Table 17](#).

9.3.4.1.3DV D2 *Modification of 9.3.4.1.3 by adding the following:*

For standard fault short circuit tests, the power factor of the test circuit shall be as indicated in [Table 17](#), or to Table 53.3 of UL 508 or Table 24 of CSA C22.2 No. 14 at the discretion of the manufacturer. For high capacity short circuit tests, the power factor of the test circuit shall be as indicated in [Table 9.3.4.2.2DV.3.1.2](#).

9.3.4.1.4 Time-constant of the test circuit

Subclause 8.3.4.1.4 of IEC 60947-1 applies.

9.3.4.1.5 Calibration of the test circuit

Subclause 8.3.4.1.5 of IEC 60947-1 applies.

9.3.4.1.6 Test procedure

Subclause 8.3.4.1.6 of IEC 60947-1 applies with the following additions.

The contactor or the starter and its associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall be mounted and connected as in normal use. They shall be connected in the test circuit using a maximum of 2,4 m of cable (corresponding to the operational current of the starter) for each main circuit.

If the SCPD is separate from the starter, it shall be connected to the starter using the cable specified above. (The total length of cable shall not exceed 2,4 m.)

Three-phase tests are considered to cover single-phase applications.

9.3.4.1.6DV D2 Modification of 9.3.4.1.6 by adding the following:

9.3.4.1.6DV.1 The wire size shall be determined in accordance with CSA C22.2 No. 60947-1/UL 60947-1, Clause 7.1.8.2DV. For motor control devices rated more than 149 kW (200 horsepower) per Annex G, Table G.1, the line and load connections may be made with bus bars equivalent in cross-sectional area to the wires specified.

9.3.4.1.6DV.2 The test wires may exceed 2,4 meters in length when they are in the circuit during calibration.

9.3.4.1.7 Void

9.3.4.1.8 Interpretation of records

Subclause 8.3.4.1.8 of IEC 60947-1 applies.

9.3.4.2 Conditional short-circuit current of contactors, starters, combination starters, combination switching devices, protected starters and protected switching devices

The contactor or starter and the associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall be subjected to the tests given in [9.3.4.2.1](#) and [9.3.4.2.2](#). The tests shall be so conducted that conditions of maximum I_e and of maximum U_e for utilization category AC-3 are covered.

For a magnetically operated contactor or starter, the magnet shall be held closed by a separate electrical supply at the rated control supply voltage U_s . The SCPD used shall be as stated in [8.2.5.1](#). If the SCPD is a circuit-breaker with an adjustable current setting, the test shall be done with the circuit-breaker adjusted to the maximum setting for the declared type of co-ordination and discrimination.

During the test, all openings of the enclosure shall be closed as in normal service and the door or cover secured by the means provided.

A starter covering a range of motor ratings and equipped with interchangeable overload relays shall be tested with the overload relay with the highest impedance and the overload relay with the lowest impedance together with the corresponding SCPDs.

For type "1" co-ordination, a new test sample may be used for each operation stated in [9.3.4.2.1](#) and [9.3.4.2.2](#).

For type "2" co-ordination, one sample shall be used for the tests at the prospective current " r " (see [9.3.4.2.1](#)) and one sample for the tests at current I_q (see [9.3.4.2.2](#)).

By agreement of the manufacturer, the tests at r and I_q may be carried out on the same sample.

9.3.4.2DV D2 Add 9.3.4.2DV.1 and 9.3.4.2DV.2 to 9.3.4.2 as follows:

9.3.4.2DV.1 Selection of SCPD

9.3.4.2DV.1.1 Tests shall be performed with SCPD selected and sized in accordance with CSA C22.1 (CE Code), Section 28-200 and Table 29, and NFPA 70 (NEC) Article 430-52 and Table 430-52. When the test is conducted with an SCPD having an ampere rating less than the maximum specified, the product shall be marked to indicate the type and rating of the SCPD as in [6.2DV.2.1](#).

9.3.4.2DV.1.2 Motor control devices, overload relays, and starters shall be subjected to a short-circuit test while protected by fuses, and a short-circuit test while protected by an inverse-time circuit breaker, except where marked in accordance with [6.2DV.2.1\(d\)](#).

9.3.4.2DV.1.3 For a contactor or starter marked for group installation, the protective device(s) shall be selected in accordance with [9.3.4.2DV.1.1](#), except the maximum size of the branch circuit protective device shall not exceed the ampere rating calculated from the following formula:

$$\text{Amperes} = [9,6 \times (\text{maximum wire size})] - [2,2 \times (\text{minimum motor FLA})]$$

The maximum wire size is the ampacity of the largest conductor size for which the device terminals have been evaluated. The conductor ampacity shall be determined per CSA C22.2 No. 60947-1/UL 60947-1, Clause 7.1.8.2DV. The minimum motor FLA shall be the smallest rated operational current (or equivalent rated operational current from kW/horsepower rating per Annex G) marked on the device.

9.3.4.2DV.1.4 A motor control device capable of being used with protective devices having ratings above and below 600 amperes shall be tested with a 600 ampere one-time, non-renewable fuse at 10 000 amperes in addition to the tests with the maximum rated fuse.

9.3.4.2DV.1.5 For a motor control device or an overload relay intended to be used with fuses, the protective devices used for the test shall be selected as follows:

- a) When the fuse size is 600 A or less, tests shall be conducted with Class RK5 fuses; or other than Class RK5 fuses if the equipment is marked in accordance with [6.2DV.2.1\(f\)](#). Testing with Class RK5 fuses is considered representative of tests using Class CC, G, H, K, J, RK1, or T fuses. Class H or K fuses shall not be used for motor-branch-circuit protection with a motor control device rated more than 50 horsepower (37 kW).
- b) When the fuse size exceeds 600 A, tests shall be conducted with Class L fuses.

9.3.4.2DV.1.6 In the United States, when intended to be installed in a group installation on the load side of a manual motor controller that has been previously found suitable for tap conductor protection, a motor controller may be additionally tested on the load side of that specified manual motor controller. No additional overcurrent protective devices shall be included in the test circuit. See [6.2DV.2.5](#) for marking requirements.

9.3.4.2DV.2 Sample selection for overload relay

9.3.4.2DV.2.1 An overload relay furnished as part of a particular motor control device shall be tested with that motor control device. A shunt or current transformer that is used to reduce the current in the current element of the overload relay shall be considered to be a part of the relay.

a) For an overload relay provided with a current transformer, when the overload relay current transformer saturates at less than the specified short-circuit current, the short-circuit test specified may be conducted at the level at which the current transformer saturates.

b) An overload relay not provided with a current transformer shall comply with the short-circuit test using the maximum current that can be applied to the input of the overload relay as specified by the manufacturer.

9.3.4.2DV.2.2 Overload relays supplied by current transformers which limit the current to the relay may be exempt from this test, provided that the current is limited to a level at which the overload relay has already been evaluated.

9.3.4.2.1 Test at the prospective current " I_r "

The circuit shall be adjusted to the prospective test current corresponding to the rated operational current I_e according to [Table 13](#) or preferably [Table 17](#) at the discretion of the manufacturer. Both tables are considered equivalent for the product to comply with this standard.

The contactor or starter and the associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall then be connected in the circuit. The following sequence of operations shall be performed:

a) one breaking operation of the SCPD shall be performed with all the switching devices closed prior to the test ("O" operation);

b) one breaking operation of the SCPD shall be performed by closing the contactor or starter on to the short-circuit ("CO" operation).

9.3.4.2.1DV D2 Modification of 9.3.4.2.1 by replacing the first paragraph with the following:

The circuit shall be adjusted to the prospective test current corresponding to the rated operational current I_e according to [Table 17](#), or to Table 53.3 of UL 508 or Table 24 of CSA C22.2 No. 14 at the discretion of the manufacturer.

Table 13
Value of the prospective test current according to the rated operational current

Rated operational current I_e (AC-3) ^a A	Prospective current "I" kA
$I_e \leq 16$	1
$16 < I_e \leq 63$	3
$63 < I_e \leq 125$	5
$125 < I_e \leq 315$	10
$315 < I_e \leq 630$	18
$630 < I_e \leq 1\,000$	30
$1\,000 < I_e \leq 1\,600$	42
$1\,600 < I_e$	Subject to agreement between manufacturer and user

^a If the contactor or starter is not specified according to utilization category AC-3, the prospective current "I" shall be subject of agreement between manufacturer and user.

Table 17
Value of the prospective test current according to the rated operational current (harmonized table)

Rated operational current I_e (AC-3) ^{a, e} A	Prospective current "I" kA ^f	Power factor
$I_e \leq 12$	1	0,7 - 0,8
$12 < I_e \leq 50$ ^b	3	0,7 - 0,8
$50 < I_e \leq 100$ ^c	5	0,7 - 0,8
$100 < I_e \leq 250$ ^d	10	0,5 - 0,7
$250 < I_e \leq 500$	18	0,2 - 0,3
$500 < I_e \leq 800$	30	0,2 - 0,3
$800 < I_e \leq 1\,300$	42	0,2 - 0,3
$1\,300 < I_e$	Subject to agreement between manufacturer and user.	0,2 - 0,3

^a If the contactor or starter is not specified according to utilization category AC-3, the prospective current "I" shall be subject of agreement between manufacturer and user.

^b at 690 V and above: $12 < I_e \leq 63$

^c at 690 V and above: $63 < I_e \leq 125$

^d at 690 V and above: $125 < I_e \leq 250$

^e Rated operational current may be marked "motor full load current" in North America.

^f Prospective current "I" may be called "standard fault current" in North America.

NOTE [Table 17](#) has been introduced for harmonization purpose with UL 60947-4-1 and is equivalent to UL 60947-4-1.

9.3.4.2.2 Test at the rated conditional short-circuit current I_q

NOTE This test is done if the current I_q is higher than the current "I".

The circuit shall be adjusted to the prospective short-circuit current I_q equal to the rated conditional short-circuit current.

If the SCPD is a fuse and the test current is within the current-limiting range of the fuse, then, if possible, the fuse shall be selected to permit the maximum peak let-through current (I_p) and the maximum let-through energy (I^2t).

The contactor or starter and the associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall then be connected to the circuit.

The following sequence of operations shall be performed:

- a) one breaking operation of the SCPD shall be performed with all the switching devices closed ("O" operation) prior to the test.
- b) one breaking operation of the SCPD shall be performed by closing ("CO" operation) the contactor or starter on to the short-circuit.
- c) in the case of a combination starter or a protected starter, with the switching device of the SCPD having a short-circuit breaking capacity or rated conditional short-circuit current less than the rated conditional short circuit current of the combination starter or protected starter the following additional test shall be made. One breaking operation of the SCPD shall be performed by closing ("CO" operation) the switching device (switch or circuitbreaker) on to the short-circuit, the contactor or starter already being closed. This operation may be performed either on a new sample (starter and SCPD) or on the first sample with the agreement of the manufacturer. After this operation only conditions a) to g) of [9.3.4.2.3](#) shall be verified.

9.3.4.2.2DV D2 Modification of 9.3.4.2.2 by replacing it with 9.3.4.2.2DV.1 to 9.3.4.2.2DV.3 and Tables 9.3.4.2.2DV.3.1.1 and 9.3.4.2.2DV.3.1.2 as follows:

9.3.4.2.2DV.1 High available fault current circuits (Optional)

The optional requirements in this section cover use on circuits having available short-circuit currents in excess of the minimum levels specified in [Table 17](#), and not more than 200 000 amperes rms symmetrical or Table 53.3 of UL 508 or Table 24 of CSA C22.2 No. 14 at the discretion of the manufacturer.

9.3.4.2.2DV.2 Protective devices

9.3.4.2.2DV.2.1 Circuit breakers

The circuit breaker used for the test shall be selected from commercially available units of the molded case type having essentially the same characteristics with respect to peak let-through current and a clearing I^2t without current limiting features, unless specific circuit breakers are marked for use with the controller.

9.3.4.2.2DV.2.2 Fuses

When tested on a single-phase circuit, fuses used for the test shall permit a peak let-through and clearing I^2t not less than the maximum value established for the fuse class intended to be used with the controller being tested. For a fuse with I_p and I^2t limits established for several different short-circuit current levels, the test fuse shall be selected to have at least the maximum values of the current corresponding to the marked short-circuit current rating of the motor control device.

9.3.4.2.2DV.3 Procedure

The equipment shall be subjected to the number and type of operations in accordance with [Table 9.3.4.2.2DV.3.1.1](#).

Table 9.3.4.2.2DV.3.1.1
Required number of short-circuit test operations (high fault current)

([9.3.4.2.2DV.3](#))

Disconnecting means provided	Type of test	Number of test operations
Yes	Disconnecting means closed on the circuit ("CO" operation)	1 ^{a, b}
Yes	Motor control device closed on the circuit ("CO" operation)	1 ^a
Yes	Circuit closed on the equipment ("O" operation)	1
No	Motor control device closed on the circuit ("CO" operation)	1
No	Circuit closed on the equipment ("O" operation)	1 ^c
Notes a) If complete physical closure of the switching contact (e.g. current flow in all poles) is established during closing tests ("CO" shots), the withstand test ("O" shot) is not required. b) When a motor control device and its control circuit are supplied from the same source (common control), the closing test on the disconnect switch is not required. c) When a stand-alone overload relay is subjected to this test, the overload relay shall be subjected to two "O" shots closing the circuit on the equipment under test.		

Table 9.3.4.2.2DV.3.1.2
Short circuit power factors for high capacity tests) (I_q)

([9.3.4.1.3DV](#))

Test current, amperes ^a	Power factor ^b
10 000 amperes or less	0,7 – 0,8
10 001 – 20 000	0,25 – 0,30
Greater than 20 000	0,15 – 0,20
^a Symmetrical rms amperes ^b Lower power factor circuits than specified may be used	

9.3.4.2.3 Results to be obtained

The contactor, starter, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall be considered to have passed the tests at the prospective current " r " and, where applicable, the prospective current I_q , if the following conditions are met for the claimed type of co-ordination.

Both types of co-ordination (all devices):

- a) The fault current has been successfully interrupted by the SCPD, the combination starter or the combination switching device and the fuse or fusible element or solid connection between the enclosure and supply shall not have melted.
- b) The door or cover of the enclosure has not been blown open and it is possible to open the door or cover. Deformation of the enclosure is considered acceptable provided that the degree of protection by the enclosure is not less than IP2X.
- c) There is no damage to the conductors or terminals and the conductors have not been separated from the terminals.
- d) There is no cracking or breaking of an insulating base to the extent that the integrity of mounting of a live part is impaired.

Both types of co-ordination (combination starters, combination switching devices, protected starters and protected switching devices only):

- e) The circuit-breaker or the switch is capable of being opened manually by its operating means.
- f) Neither end of the SCPD is completely separated from its mounting means to an exposed conductive part.
- g) If a circuit-breaker with rated ultimate short-circuit breaking capacity less than the rated conditional short-circuit current assigned to the combination starter, the combination switching device, the protected starter or the protected switching device is employed, the circuit-breaker shall be tested to trip as follows:
 - 1) circuit-breakers with instantaneous trip relays or releases: at 120 % of the trip current.
 - 2) circuit-breakers with overload relays or releases: at 250 % of the rated current of the circuit-breaker.

Type "1" co-ordination (all devices):

- h) There has been no discharge of parts beyond the enclosure. Damage to the contactor and the overload relay is acceptable. The starter may be inoperative after each operation. The starter shall therefore be inspected and the contactor and/or the overload relay and the release of the circuit-breaker shall be reset if necessary and, in the case of fuse protection, all fuse-links shall be replaced.

Type "1" co-ordination (combination and protected starters only):

- i) The adequacy of insulation in accordance with 8.3.3.4.1, item 4), of IEC 60947-1 is verified after each operation (at currents " I_r " and " I_q ") by a dielectric test on the complete unit under test (SCPD plus contactor/starter but before replacement of parts) using a power frequency withstand voltage of twice the rated operational voltage U_e but not less than 1 000 V. The test voltage shall be applied to the incoming supply terminals, with the switch or the circuit-breaker in the open position, as follows:

- between each pole and all other poles connected to the frame of the starter;
- between all live parts of all poles connected together and the frame of the starter;
- between the terminals of the line side connected together and terminals of the other side connected together.

For equipment suitable for isolation, the leakage current shall be measured through each pole, with the contacts in the open position, at a test voltage of $1,1 U_e$ and shall not exceed 6 mA.

Type "2" co-ordination (all devices):

j) No damage to the overload relay or other parts has occurred, except that welding of contactor or starter contacts is permitted, if they are easily separated (e.g. by a screwdriver) without significant deformation, but no replacement of parts is permitted during the test, except that, in the case of fuse protection, all fuse-links shall be replaced.

In the case of welded contacts as described above, the functionality of the device shall be verified by carrying out 10 operating cycles under the conditions of [Table 10](#) for the applicable utilization category.

k) The tripping of the overload relay shall be verified at a multiple of the current setting and shall conform to the published tripping characteristics, according to [5.7.5](#), both before and after the short circuit test.

l) The adequacy of the insulation in accordance with 8.3.3.4.1, item 4), of IEC 60947-1 shall be verified by a dielectric test on the contactor, the starter, the combination starter, the combination switching device, the protected starter or the protected switching device, using a power frequency withstand voltage of twice the rated operational voltage U_e but not less than 1 000 V.

In the case of combination starters, combination switching devices, protected starters and protected switching devices, additional tests according to 8.3.3.4.1, item 3), of IEC 60947-1 shall be made across the main poles of the device with the contacts of the switch or of the circuit-breaker open and the contacts of the starter closed.

For equipment suitable for isolation, the leakage current shall be measured through each pole, with the contacts in the open position, at a test voltage of $1,1 U_e$ and shall not exceed 2 mA.

Fuse-links, if any, are shorted.

9.3.4.2.3DV.1 D2 Modification of 9.3.4.2.3 by adding the following to Item b):

As an alternative, the accessibility of live parts may be evaluated in accordance with UL 508, Clauses 7.17.1 – 7.17.5 and CSA C22.2 No. 14, Clause 4.2.5

9.3.4.2.3DV.2 D2 Modification of 9.3.4.2.3 by replacing "120 %" with "130 %" in Item g) 1).

9.3.5 Overload current withstand capability of contactors

For the test, the contactor shall be mounted, wired and operated as specified in [9.3.2](#).

All poles of the contactors are simultaneously subjected to one test with the overload current and duration values stated in [8.2.4.4](#). The test is performed at any convenient voltage and it starts with the contactor at room temperature.

After the test, the contactor shall be substantially in the same condition as before the test. This is verified by visual inspection.

NOTE The I^2t value (Joule integral) calculated from this test cannot be used to estimate the performance of the contactor under short-circuit conditions.

9.3.6 Routine tests and sampling tests

9.3.6.1 General

The tests shall be carried out under the same conditions as those specified for type tests in the relevant parts of [9.1.2](#) or under equivalent conditions. However, the limits of operation in [9.3.3.2](#) may be verified at the prevailing ambient air temperature and on the overload relay alone, but a correction may be necessary to allow for normal ambient conditions.

If devices are tested separately, their combination shall be tested with the dielectric test and other relevant operational tests. However, if the combination is built up with already tested connection systems or auxiliaries, an additional dielectric test is not necessary.

9.3.6.2 Operation and operating limits

For electromagnetic, pneumatic and electro-pneumatic contactors or starters, tests are carried out to verify operation within the limits specified in [8.2.1.2](#).

For manual starters, tests are carried out to verify the proper operation of the starter (see [8.2.1.2](#), [8.2.1.3](#) and [8.2.1.4](#)).

NOTE 1 In these tests it is not necessary to reach thermal equilibrium. The lack of thermal equilibrium may be compensated by using a series resistor or by appropriately decreasing the voltage limit.

Tests shall be made to verify the calibration of relays. In the case of a time delay overload relay, this may be a single test with all poles equally energized at a multiple of the current setting, to check that the tripping time conforms (within tolerances) to the curves supplied by the manufacturer; in the case of an instantaneous magnetic overload relay, the test shall be carried out at 1,1 times the current setting. For under-current relays, stall relays and jam relays, tests shall be carried out to verify the proper operation of these relays (see [8.2.1.5.4](#), [8.2.1.5.5](#) and [8.2.1.5.6](#)).

NOTE 2 In the case of a time-delay magnetic overload relay comprising a time-delay device working with a fluid dashpot, calibration may be carried out with the dashpot empty, at a percentage of the current setting indicated by the manufacturer and capable of being justified by a special test.

9.3.6.3 Dielectric tests

9.3.6.3.1 General

Subclause 8.3.3.4.2 of IEC 60947-1 applies with the following addition.

In the case of a rheostatic rotor starter, all the poles of the rotor switching devices will normally be connected through the starting resistors; the dielectric test is therefore confined to the application of the test voltage between the rotor circuit and the frame of the starter.

The use of the metal foil is not necessary.

NOTE The combined test of 8.3.3.4.2 of IEC 60947-1 is permitted.

9.3.6.3.2 Routine power frequency test for devices incorporating voltage limiting components

At the discretion of the manufacturer, the device incorporating voltage limiting components are to be tested with the following sequence a) to b):

a) Application of the test voltage

The test shall be performed in accordance with 8.3.3.4.2 2) of IEC 60947-1:2007. The value of the test voltage shall be the U_V r.m.s. value (max. operational voltage of the voltage limiting components) or the maximum U_V d.c. value of the voltage limiting components with a tolerance of -10 %.

Acceptance criteria: The over-current relay of the test apparatus shall not trip (lower tripping limit).

b) Verification of the proper function of the voltage limiting components

The test shall be performed in accordance with 8.3.3.4.2 2) of IEC 60947-1:2007. The value of the test voltage shall be chosen by the manufacturer so that a current is generated between the upper tripping limit and the lower tripping limit of the test apparatus.

Acceptance criteria: The current shall be between a) and b) and the voltage limiting component shall not be damaged.

NOTE The main purpose of this test is to check the proper operation of the voltage limiting component.

9.4 EMC Tests

9.4DV D2 Modification of 9.4 and all subclauses by adding the following:

Clause 9.4 is informative.

9.4.1 General

Subclauses 8.3.2.1, 8.3.2.3 and 8.3.2.4 of IEC 60947-1 apply with the following additions.

With the agreement of the manufacturer, more than one EMC test or all EMC tests may be conducted on one and the same sample, which may initially be new or may have passed test sequences according to [9.3.1](#). The sequence of the EMC tests may be any convenient sequence.

The test report shall include any special measures that have been taken to achieve compliance, for example the use of shielded or special cables. If auxiliary equipment is used with the contactor or starter in order to comply with immunity or emission requirements, it shall be included in the report.

The test sample shall be in the open or closed position, whichever is the worse, and shall be operated with the rated control supply.

9.4.2 Immunity

The tests of [Table 14](#) are required. Special requirements are specified in [9.4.2.1](#) to [9.4.2.7](#).

If, during the EMC-tests, conductors are to be connected to the test sample, the cross-section and the type of the conductors are optional but shall be in accordance with the manufacturer's literature.

Table 14
EMC immunity tests

Type of test	Test level required
Electrostatic discharge immunity test IEC 61000-4-2	Corresponding test level of Table 23 of IEC 60947-1 applies.
Radiated radio-frequency electromagnetic field immunity test (80 MHz to 1 GHz and 1,4 GHz to 2 GHz) IEC 61000-4-3	Corresponding test level of Table 23 of IEC 60947-1 applies.
Electrical fast transient/burst immunity test IEC 61000-4-4 ^a	Corresponding test level of Table 23 of IEC 60947-1 applies.
1,2/50 μ s – 8/20 μ s surge immunity test IEC 61000-4-5	Corresponding test level of Table 23 of IEC 60947-1 applies.
Conducted disturbances induced by radio-frequency fields immunity test ^{b c} (150 kHz to 80 MHz) IEC 61000-4-6	Corresponding test level ^d of Table 23 of IEC 60947-1 applies.
^a The contactor shall be operated at least one time during the test and the overload relay is loaded at 0,9 times the current setting with a maximum of 100 A. ^b Applicable to ports only interfacing with cables whose total length according to the manufacturer's functional specification may exceed 3 m. ^c The test level can also be defined as the equivalent current into a 150 Ω load. ^d Except for the ITU broadcast frequency band 47 MHz to 68 MHz, where the level shall be 3 V.	

9.4.2.1 Performance of the test sample during and after the test

Unless otherwise specified, performance criterion B applies, see [8.3.2.2](#).

No loss of performance shall be permitted during or after the tests. After the tests the operating limits of [9.3.6.2](#) shall be verified at ambient temperature.

9.4.2.2 Electrostatic discharge

The test shall be conducted using the methods of IEC 61000-4-2.

Except for metallic parts for which contact discharge is made, only air discharge is required.

Ten positive and ten negative pulses shall be applied to each selected point, the time interval after each successive single discharge being 1 s.

Tests are not required on power terminals. The application of conductors is not required, except for energizing the coil.

9.4.2.3 Electromagnetic field

The tests shall be conducted using the methods of IEC 61000-4-3. The test procedure of IEC 61000-4-3 shall apply.

The device shall comply with performance criterion A.

9.4.2.4 Fast transient bursts

The tests shall be conducted using the methods of IEC 61000-4-4 with a repetition rate of 5 kHz.

The bursts shall be applied to all main, control or auxiliary terminals, whether they comprise electronic or conventional contacts.

The test voltage shall be applied for the duration of 1 min.

9.4.2.5 Surges (1,2/50 μ s – 8/20 μ s)

The test shall be conducted using the methods of IEC 61000-4-5. Capacitive coupling shall be preferred. The surges shall be applied to all main, control or auxiliary terminals, whether they comprise electronic or conventional contacts.

The test voltage values are those of [Table 14](#) but shall not exceed the corresponding U_{imp} value(s) given by the manufacturer following 7.2.3 of IEC 60947-1.

The repetition rate shall be one surge per minute, with the number of pulses being five positive and five negative.

9.4.2.6 Harmonics

Under consideration.

9.4.2.7 Conducted disturbances induced by radio-frequency fields

Subclause 8.4.1.2.6 of IEC 60947-1 applies with the following addition.

The device shall comply with performance criterion A under the test conditions given in [Table 14](#).

9.4.3 Emission

For equipment designed for environment A, a suitable warning shall be given to the user (for example in the instruction manual) stipulating that the use of this equipment in environment B may cause radio interference in which case the user may be required to employ additional mitigation methods.

9.4.3.1 Conducted radio-frequency emission tests

A description of the test, the test method and the test set-up are given in CISPR 11.

To pass, the equipment shall not exceed the levels given in [Table 15](#).

Table 15
Conducted radio-frequency emission test limits

Frequency band MHZ	Environment A dB(μV)	Environment B dB(μV)
0,15 – 0,5	79 quasi-peak 66 average	66 – 56 quasi-peak 56 – 46 average (decrease with log of frequency)
0,5 – 5,0	73 quasi-peak 60 average	56 quasi-peak 46 average
5 – 30	73 quasi-peak 60 average	60 quasi-peak 50 average

9.4.3.2 Radiated radio-frequency emission tests

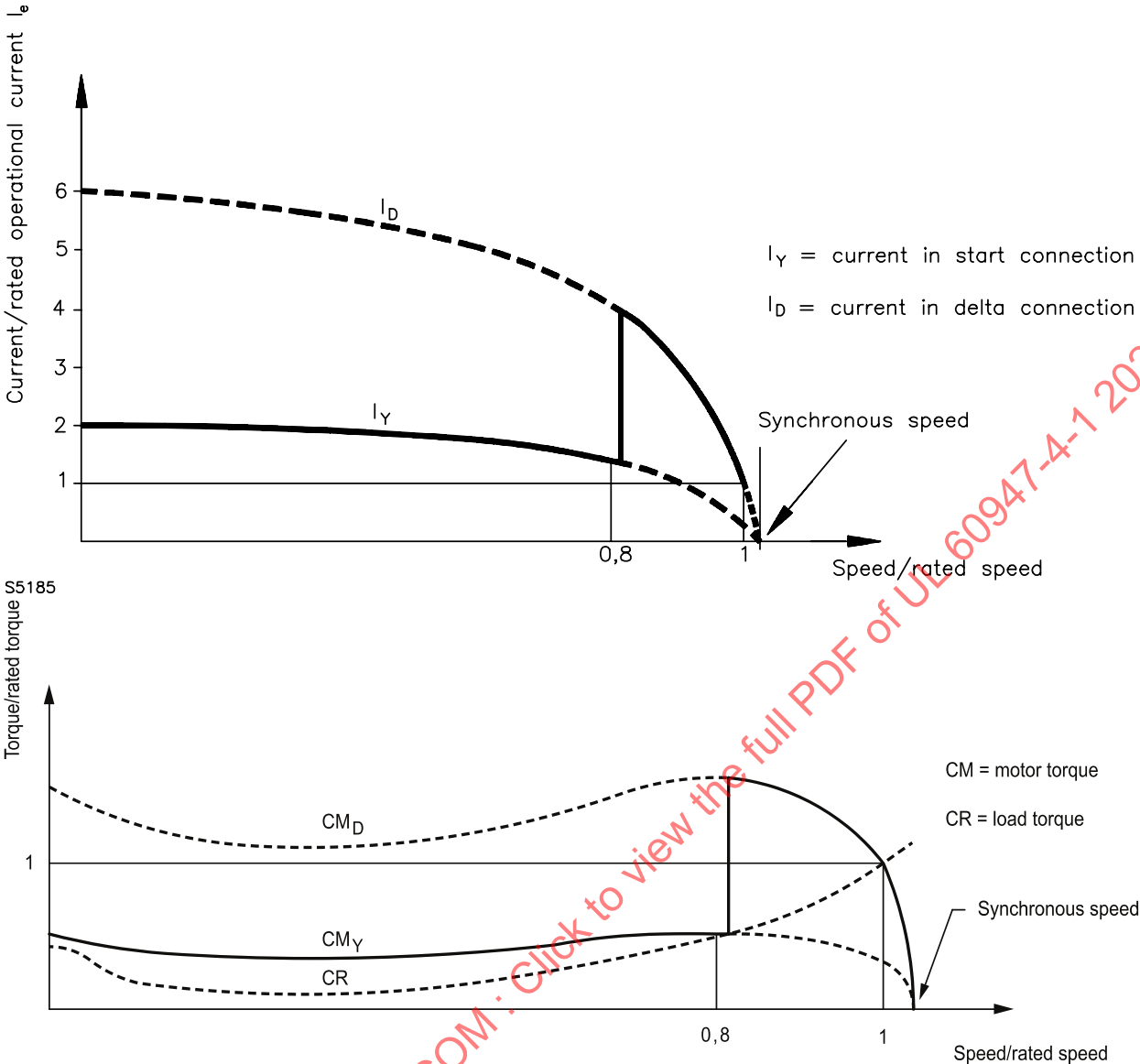
A description of the test, the test method and the test set-up are given in CISPR 11.

Tests are required where the control and auxiliary circuits contain components with fundamental switching frequencies greater than 9 kHz, for example switch-mode power supplies, etc.

To pass, the equipment shall not emit at higher levels than those given in [Table 16](#).

Table 16
Radiated emission test limits

Frequency band MHz	Environment A ^a dB(μV/m)	Environment B dB(μV/m)
30 – 230	30 quasi-peak at 30 m	30 quasi-peak at 10 m
230 – 1 000	37 quasi-peak at 30 m	37 quasi-peak at 10 m
^a These tests may be carried at 10 m distance with the limits raised by 10 dB.		



su1484

Figure 1
Typical curves of currents and torques during a star-delta start (see [1.1.2.2.1](#))

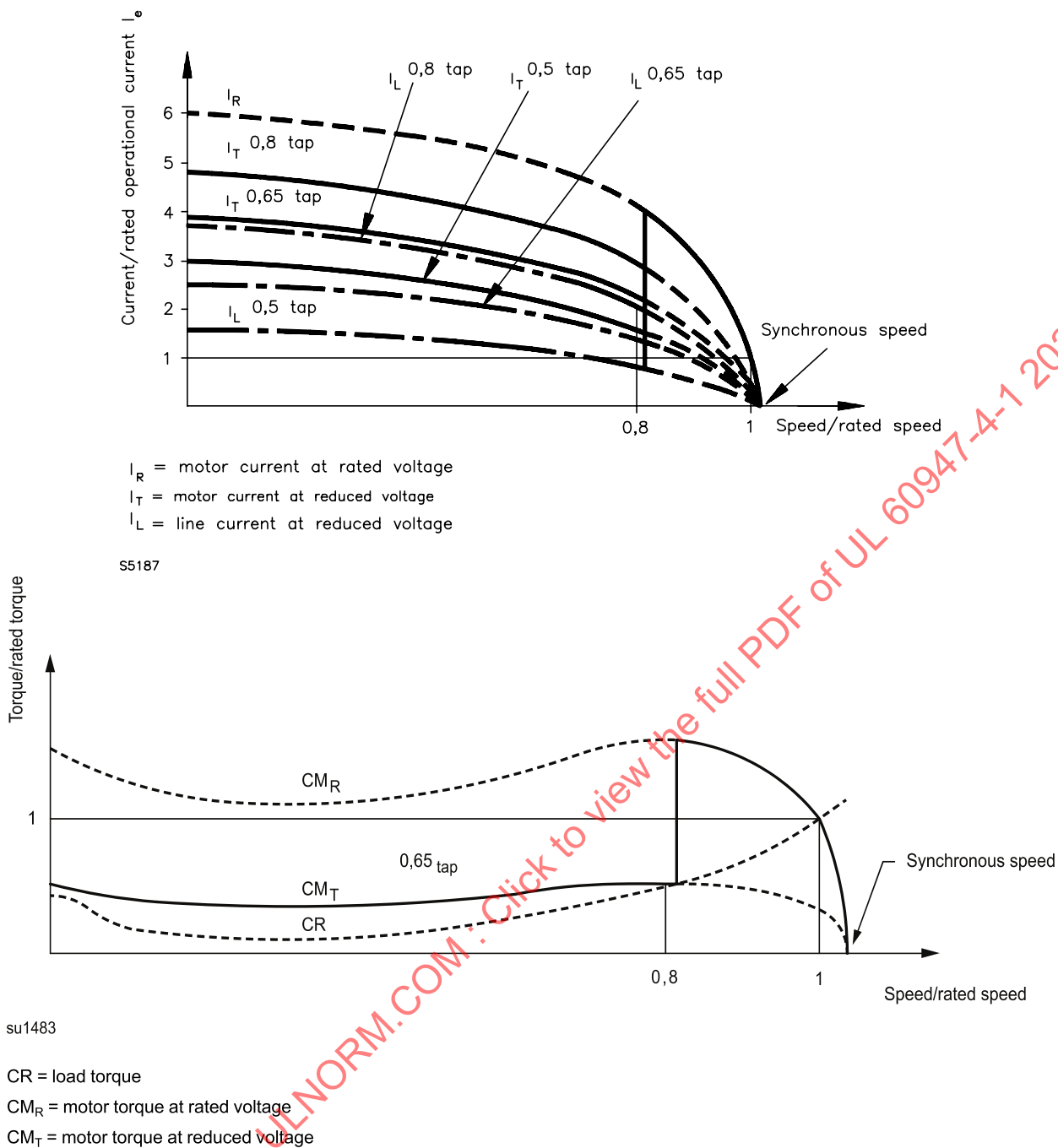
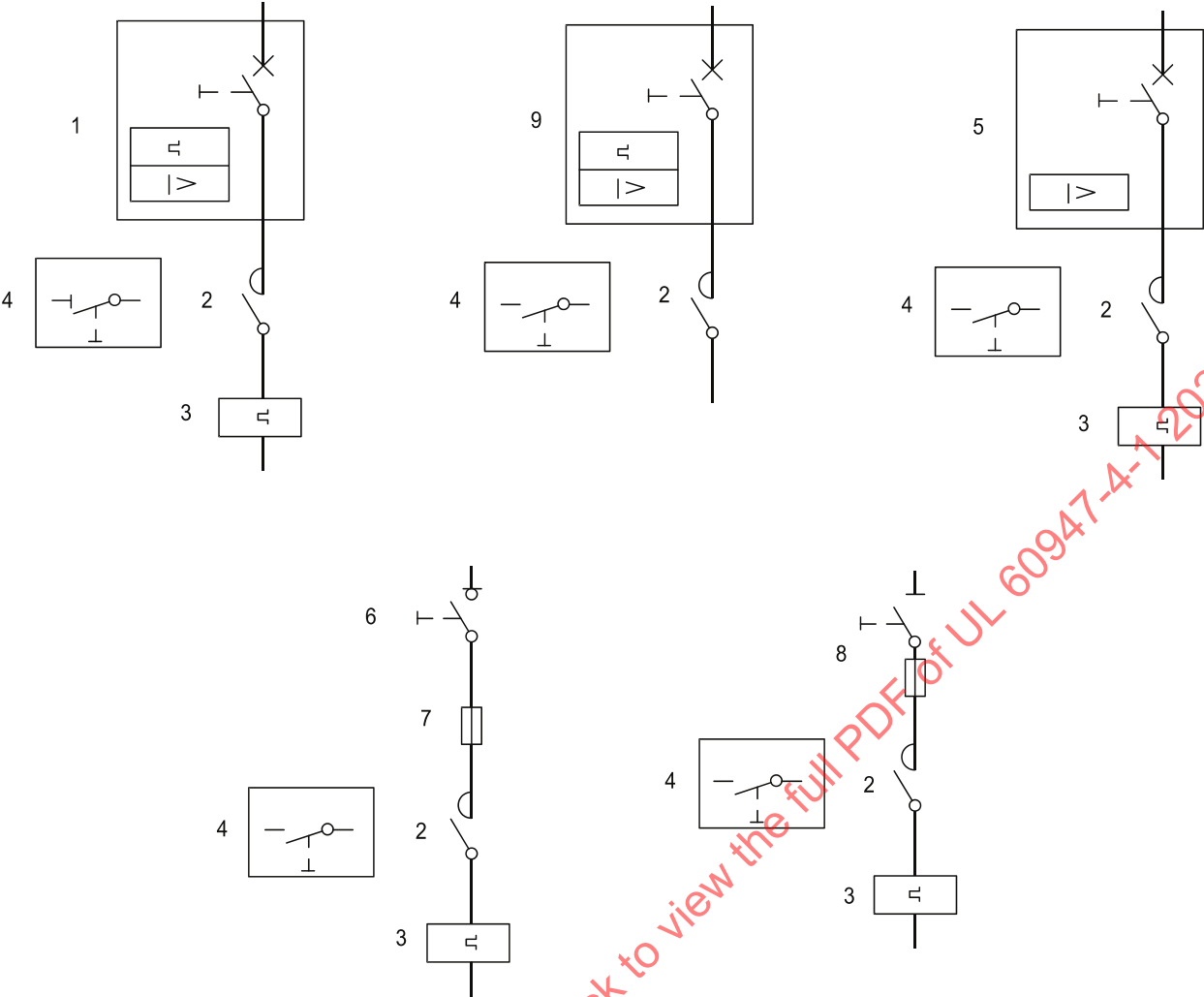


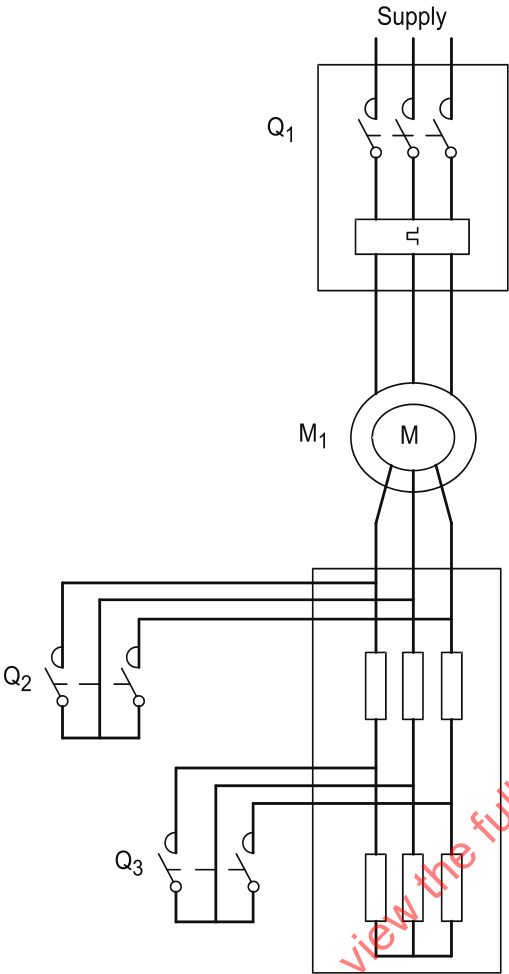
Figure 2

Typical curves of currents and torques during an auto-transformer start (see [1.1.2.2.2](#))



- s5189a
- 1 circuit-breaker according to IEC 60947-2
2 contactor
3 overload relay
4 control switch
5 circuit-breaker magnetic trip only
6 switch-disconnector
7 fuse
8 disconnecter fuse
9 motor protection circuit breaker according to this standard
- IEC

Figure 3
Typical variants of protected starters, combination starters, protected switching devices and combination switching devices



Position of the mechanical switching devices

Mechanical switching device \ Position of the starter	Starting				NO
	Stop	1st step	2nd step	3rd step	
Q ₁	O	C	C	C	<div>↓</div>
Q ₂	O	O	O	C	
Q ₃	O	O	C	C	

O mechanical switching device open

C mechanical switching device closed

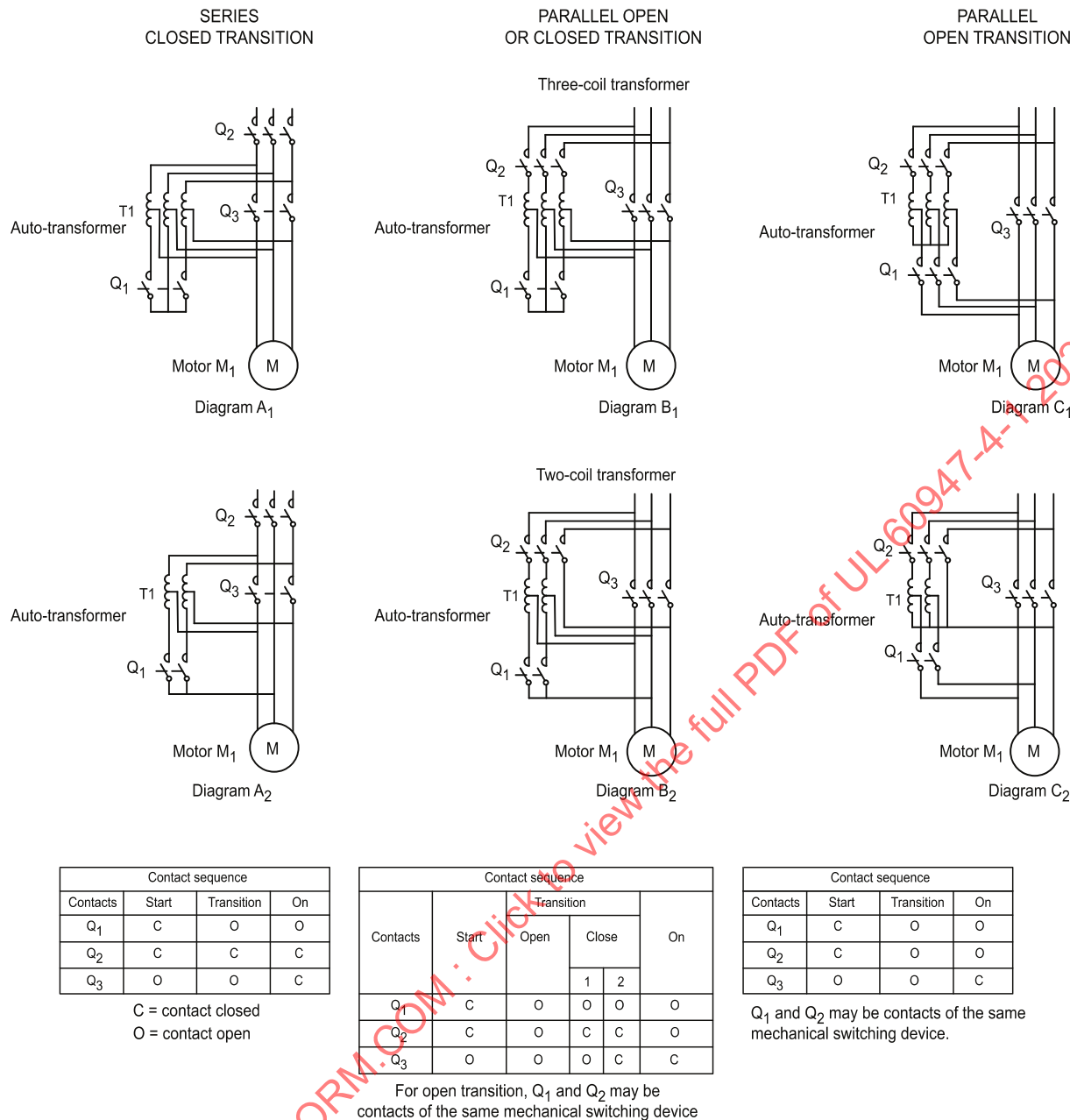
Q contactor

M motor

su1486

Figure 4

Example of three-phase diagram of a rheostatic rotor starter with three starting steps and one direction of rotation (in the case when all the mechanical switching devices are contactors)



NOTE: The graphical symbols utilized above correspond to the case where all the mechanical switching devices are contactors.

su1487

Figure 5

Typical methods and diagrams of starting alternating-current induction motors by means of auto-transformers

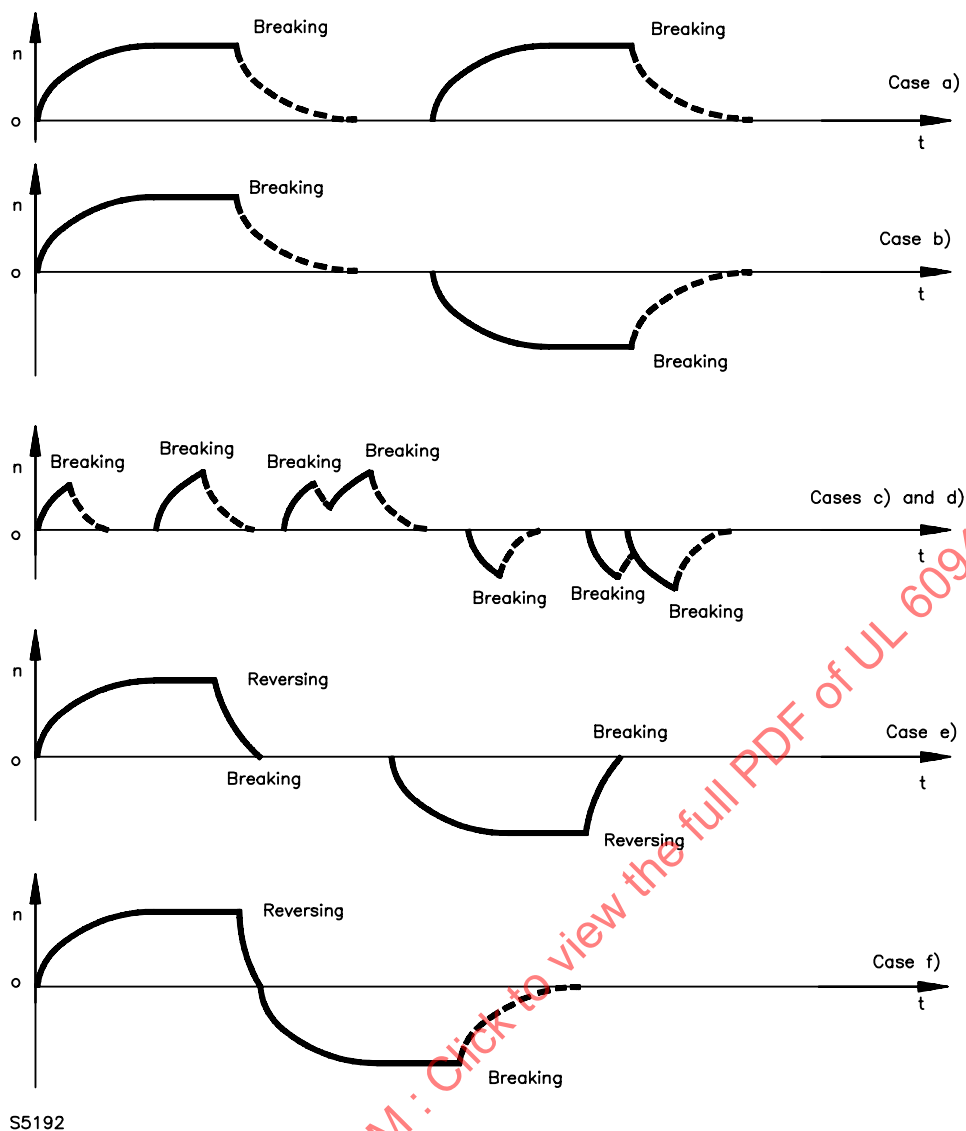
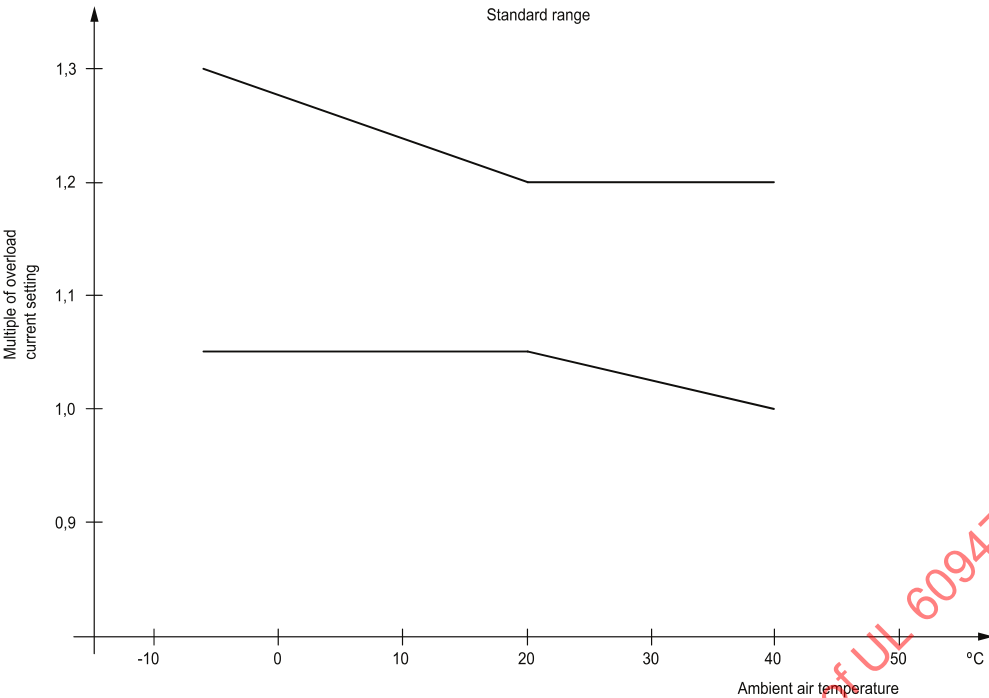


Figure 6

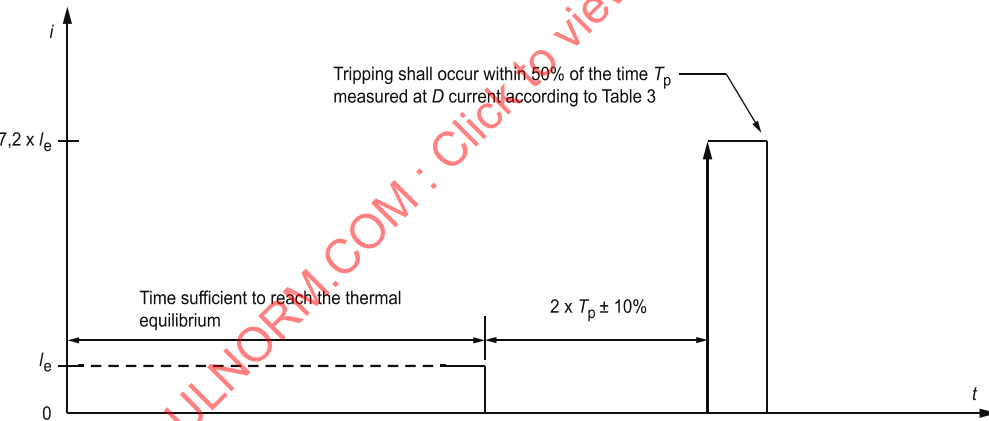
Examples of speed/time curves corresponding to cases a), b), c), d), e) and f) of [5.3.5.5](#) (the dotted parts of the curves correspond to the periods when no current flows through the motor)



su1488

Figure 7

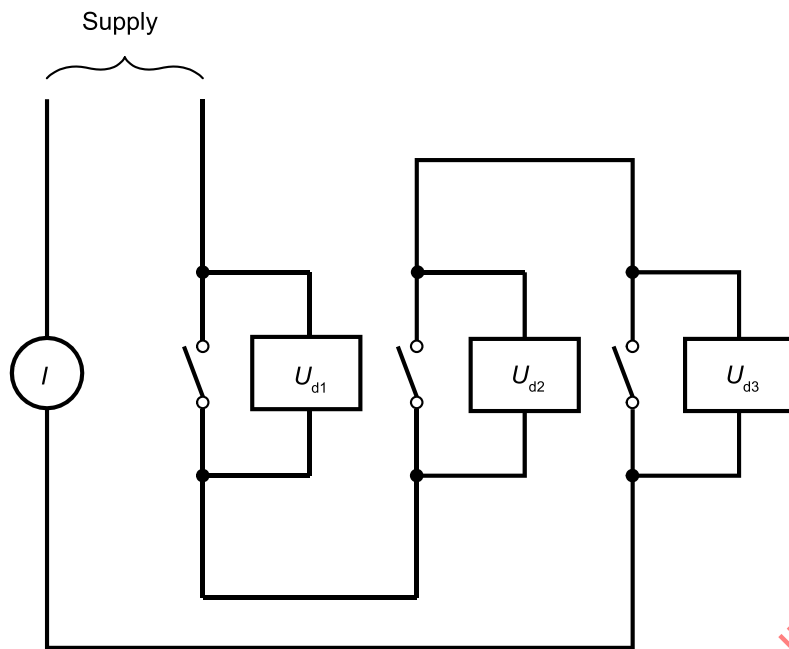
Multiple of current setting limits for ambient air temperature compensated time-delay overload relays (see [8.2.1.5.1](#))



su1489

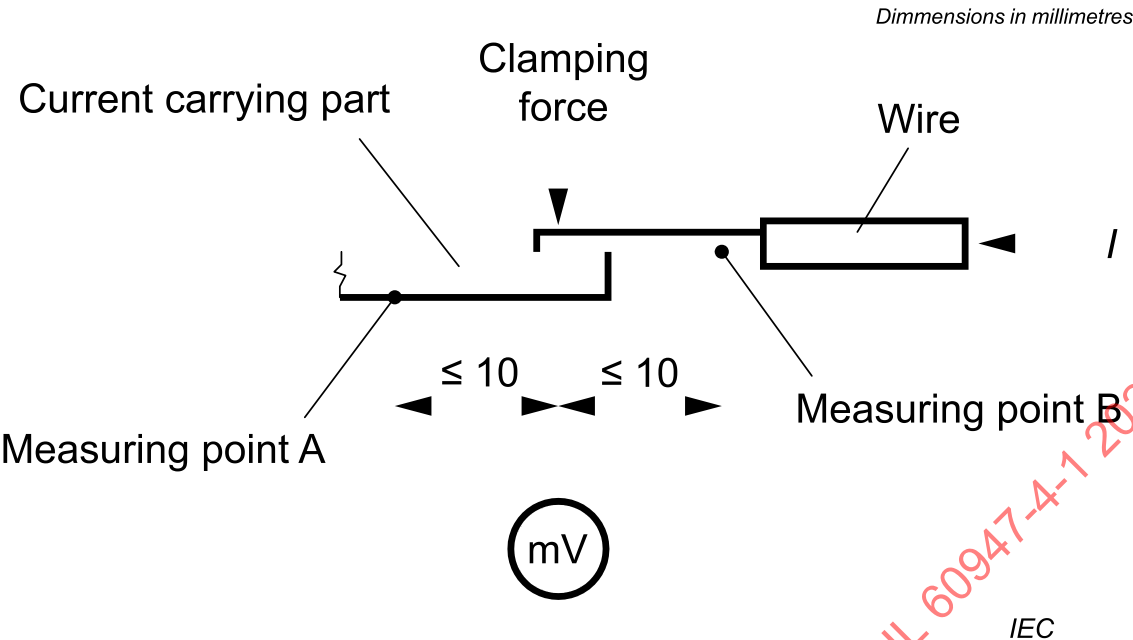
Figure 8

Thermal memory test



su4353

Figure 9**Example of a pole impedance measurement for a 3 pole contactor**



su4354

Figure 10

Voltage drop measurement at contact point of the clamping terminal

Annex A (normative)

Marking and identification of terminals of contactors and associated overload relays

Annex ADV D2 Modification to Annex A by replacing “normative” with “informative”:

Annex A is informative.

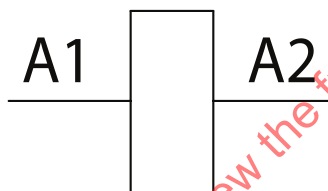
A.1 General

The purpose of identifying terminals of contactors and associated overload relays is to provide information regarding the function of each terminal or its location with respect to other terminals or for other use.

A.2 Marking and identification of terminals of contactors

A.2.1 Marking and identification of terminals of coils

In the case of identification by alphanumeric markings, the terminals of a coil for an electromagnetic contactor shall be marked A1 and A2.



S4434

For a coil with tapplings, the terminals of the tapplings shall be marked in sequential order A3, A4, etc.

EXAMPLE



S4435a

NOTE As a consequence of this, both incoming and outgoing terminals may have even or odd numbers.

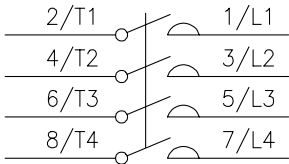
For a coil having two windings, the terminals of the first winding will be marked A1, A2 and those of the second winding B1, B2.



S4453

A.2.2 Marking and identification of terminals of main circuits

The terminals of the main circuits shall be marked by single figure numbers and an alphanumeric system.



S4454

NOTE The present alternative methods of marking, i.e. 1-2 and L1-T1, will be progressively superseded by the new method above.

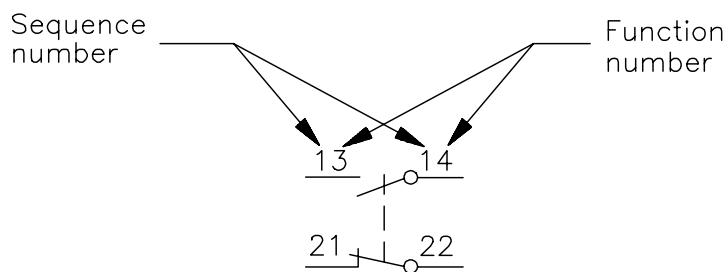
Alternatively, terminals may be identified on the wiring diagram supplied with the device.

A.2.3 Marking and identification of terminals of auxiliary circuits

The terminals of auxiliary circuits shall be marked or identified on the diagrams by two figure numbers:

- the unit number is a function number;
- the figure of the tens is a sequence number.

The following examples illustrate such a marking system:



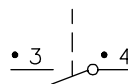
S4455

A.2.3.1 Function number

Function numbers 1, 2 are allocated to circuits with break contacts and function numbers 3, 4 to circuits with make contacts.

NOTE 1 The definitions for make contacts and break contacts are given in 2.3.12 and 2.3.13 of IEC 60947-1.

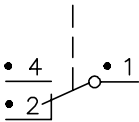
EXAMPLES



S4456

NOTE 2 The dots in the above examples take the place of the sequence numbers which should be added appropriately to the application.

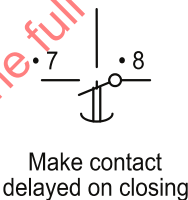
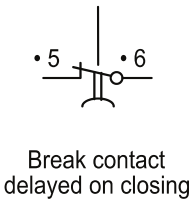
The terminals of circuits with change-over contact elements shall be marked by the function numbers 1, 2 and 4.



S4457

Function numbers 5 and 6 (for break contacts) and 7 and 8 (for make contacts) are allocated to terminals of auxiliary circuits containing auxiliary contacts with special functions.

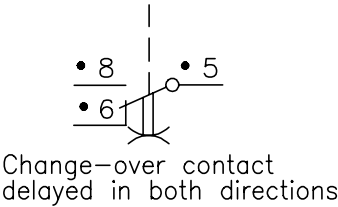
EXAMPLES



su1418

The terminals of circuits with change-over contact elements with special functions shall be marked by function numbers 5, 6 and 8.

EXAMPLE



S4459

A.2.3.2 Sequence number

Terminals belonging to the same contact element shall be marked by the same sequence number.

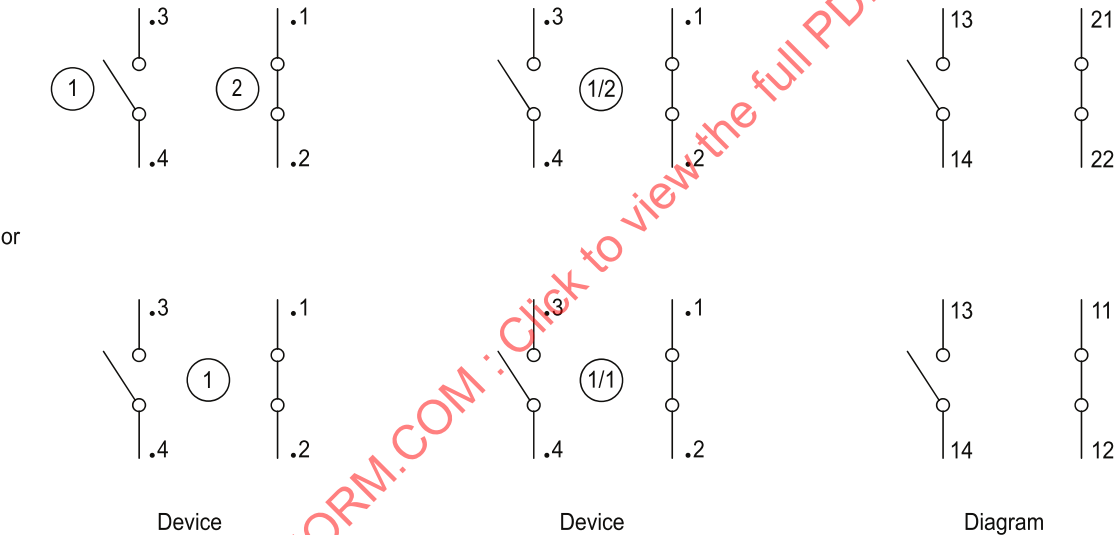
All contact elements having the same function shall have different sequence numbers.

EXAMPLES



S4460

The sequence number may be omitted from the terminals only if additional information provided by the manufacturer or the user clearly gives such a number.



su1491

NOTE The dots shown in the above examples are merely used to show the relationship and do not need to be used in practice.

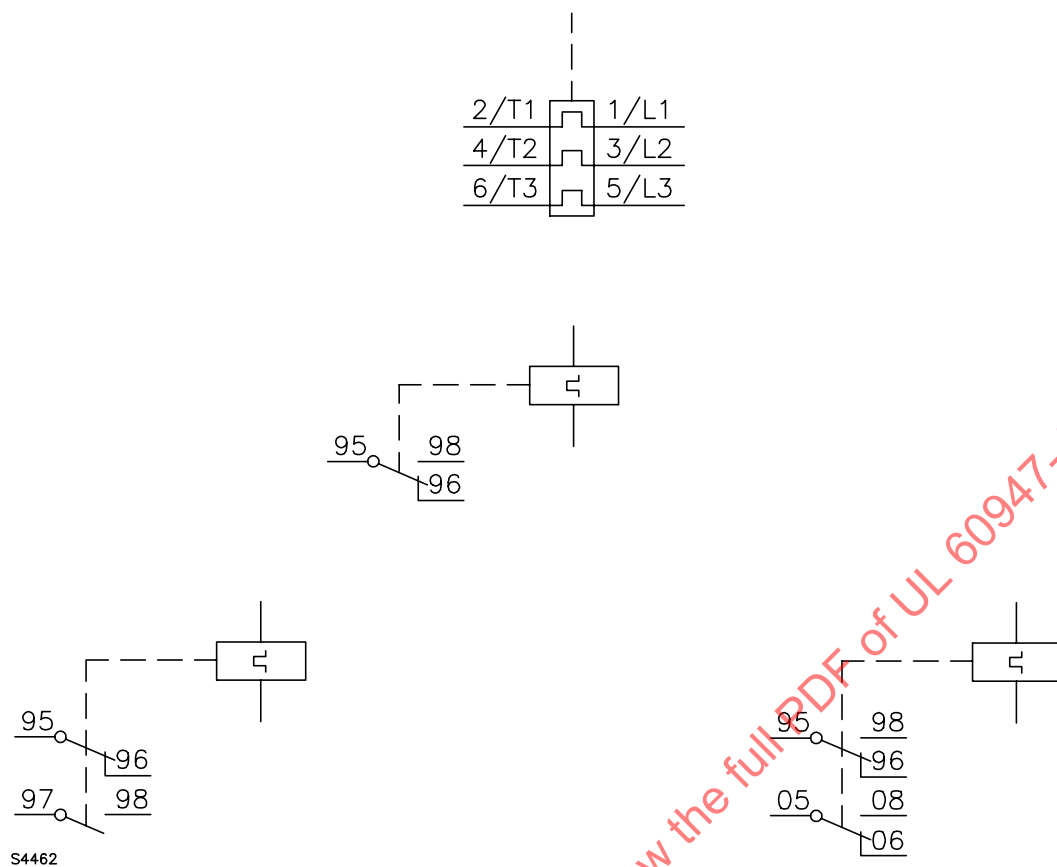
A.3 Marking and identification of terminals of overload relays

The terminals of the main circuits of overload relays shall be marked in the same manner as the terminals of the main circuits of contactors (see [A.2.2](#)).

The terminals of the auxiliary circuits of overload relays shall be marked in the same manner as the terminals of the auxiliary circuits of contactors with specified functions (see [A.2.3](#)).

The sequence number shall be 9; if a second sequence number is required, it shall be 0.

EXAMPLES



Alternatively, terminals may be identified on the wiring diagram supplied with the device.

Annex B (normative)

Special tests

Annex BDV D2 Modification to Annex B by replacing “normative” with “informative”:

Annex B is informative.

B.1 General

Special tests are done at the discretion of the manufacturer.

B.2 Mechanical durability

B.2.1 General

By convention, the mechanical durability of a design of contactor or starter is defined as the number of no-load operating cycles which would be attained or exceeded by 90 % of all the apparatus of this design before it becomes necessary to service or replace any mechanical parts; however, normal maintenance including replacement of contacts as specified in [B.2.2.1](#) and [B.2.2.3](#) is permitted.

The preferred numbers of no-load operating cycles, expressed in millions, are:

0,001 – 0,003 – 0,01 – 0,03 – 0,1 – 0,3 – 1 – 3 and 10.

B.2.2 Verification of mechanical durability

B.2.2.1 Condition of the contactor or starter for tests

The contactor or starter shall be installed as for normal service; in particular, the conductors shall be connected in the same manner as for normal use.

During the test, there shall be no voltage or current in the main circuit. The contactor or starter may be lubricated before the test if lubrication is prescribed in normal service.

B.2.2.2 Operating conditions

The coils of the control electromagnets shall be supplied at their rated voltage and, if applicable, at their rated frequency.

If a resistance or an impedance is provided in series with the coils, whether short-circuited during the operation or not, the tests shall be carried out with these elements connected as in normal operation.

Pneumatic and electro-pneumatic contactors or starters shall be supplied with compressed air at the rated pressure.

Manual starters shall be operated as in normal service.

B.2.2.3 Test procedure

a) The tests are carried out at the frequency of operations corresponding to the class of intermittent duty. However, if the manufacturer considers that the contactor or starter can satisfy the required conditions when using a higher frequency of operations, he may do so.

b) In the case of electromagnetic and electro-pneumatic contactors or starters, the duration of energization of the control coil shall be greater than the time of operation of the contactor or starter and the time for which the coil is not energized shall be of such a duration that the contactor or starter can come to rest at both extreme positions.

The number of operating cycles to be carried out shall be not less than the number of no-load operating cycles stated by the manufacturer.

The verification of mechanical durability may be made separately on the various components of the starter which are not mechanically linked together, unless a mechanical interlock not previously tested with its contactor is involved.

c) For contactors or starters fitted with releases with shunt coils or undervoltage releases, at least 10 % of the total number of opening operations shall be performed by these releases.

d) After each tenth of the total number of operating cycles given in [B.2.1](#) has been carried out, it is permissible before carrying on with the test:

- to clean the whole contactor or starter without dismantling;
- to lubricate parts for which lubrication is prescribed by the manufacturer for normal service;
- to adjust the travel and the pressure of the contacts if the design of the contactor or starter enables this to be done.

e) This maintenance work shall not include any replacement of parts.

f) In the case of star-delta starters, the built-in device causing time-delay between closing on star connection and closing on delta connection, if adjustable, may be set at its lowest value.

g) In the case of rheostatic starters, the built-in device causing time-delay between closing of the rotor switching devices, if adjustable, may be set at its lowest value.

h) In the case of auto-transformer starters, the built-in device causing time-delay between closing on the starting position and closing on the ON position, if adjustable, may be set at its lowest value.

B.2.2.4 Results to be obtained

Following the tests of mechanical durability, the contactor or starter shall still be capable of complying with the operating conditions specified in [9.3.6.2](#) and [9.3.6.3](#) at room temperature.

Any timing relays or other devices for the automatic control shall still be operating.

B.2.2.5 Statistical analysis of test results for contactors or starters

The mechanical durability of a design of a contactor or starter is assigned by the manufacturer and verified by a statistical analysis of the results of the tests.

For contactors or starters which are produced in small quantities, the tests described in [B.2.2.6](#) and [B.2.2.7](#) do not apply.

However, for contactors or starters which are produced in small quantities and which also differ from a basic design only by minor variations without notable influence on characteristics, the manufacturer may assign mechanical durability on the basis of experience with similar designs, analysis, properties of materials, etc., and on the basis of the analysis of test results on large quantity production of the same basic design.

After this assignment, one of the two tests described below shall be performed. It should be selected by the manufacturer as being the most suitable in each case, for example according to the quantities of planned production or according to the conventional thermal current.

NOTE This test is not intended to be a lot-by-lot or production acceptance test for application by the user.

B.2.2.6 Single 8 test

Eight contactors or starters shall be tested to the assigned mechanical durability.

If the number of failures does not exceed two, the test is considered passed.

B.2.2.7 Double 3 test

Three contactors or starters shall be tested to the assigned mechanical durability.

The test is considered passed if there is no failure, and failed if there is more than one failure. Should there be one failure, then three additional contactors or starters are tested up to assigned mechanical durability and, providing there is no additional failure, the test is considered passed. The test is failed if at any time there is a total of two or more failures.

B.2.2.8 Other methods

Other methods given in IEC 60410 can also be used. The maximum acceptance quality level shall be 10 %. The chosen method shall be indicated in the test report.

NOTE The single 8 test and the double 3 test are both given in IEC 60410 (see Table X-C-2 and Table X-D-2). These two tests have been chosen with the objective of basing them on testing a limited number of contactors or starters on essentially the same statistical characteristics (acceptance quality level: 10 %).

B.3 Electrical durability

B.3.1 General

With respect to its resistance to electrical wear, a contactor or starter is by convention characterized by the number of on-load operating cycles corresponding to the different utilization categories given in [Table B.1](#) which can be made without repair or replacement.

Since, for star-delta, two-step auto-transformer and rheostatic rotor starters, the operation is subjected to large variations in the service conditions, it is deemed convenient not to give standard values for the test conditions. However, it is recommended that the manufacturer indicate the electrical durability of the starter for stated service conditions; this electrical durability may be estimated from the results of tests on the component parts of the starter.

For categories AC-3 and AC-4, the test circuit shall comprise inductors and resistors so arranged as to give the appropriate values of current, voltage and power factor given in [Table B.1](#); moreover, for AC-4, the test circuit testing the making and breaking capacity shall be used, see [9.3.3.5.2](#).

In all cases, the speed of operation shall be chosen by the manufacturer.

The tests shall be taken as valid if the values recorded in the test report differ from the values specified only within the following tolerances:

– current: $\pm 5\%$;

– voltage: $\pm 5\%$.

Tests shall be carried out with the contactor or the starter under the appropriate conditions of [B.2.2.1](#) and [B.2.2.2](#) using the test procedure, where applicable, of [B.2.2.3](#), except that replacement of contacts is not permitted.

In the case of starters, if the associated contactor has already satisfied an equivalent test, the test need not be repeated on the starter.

Table B.1
Verification of the number of on-load operating cycles – Conditions for making and breaking corresponding to the several utilization categories

Utilization category	Value of the rated operational current	Make			Break		
		I/I_e	U/U_e	$\cos \varphi^a$	I_c/I_e	U_r/U_e	$\cos \varphi^a$
AC-1	All values	1	1	0,95	1	1	0,95
AC-2	All values	2,5	1	0,65	2,5	1	0,65
AC-3	$I_e \leq 17A$	6	1	0,65	1	0,17	0,65
	$I_e > 17A$	6	1	0,35	1	0,17	0,35
AC-4	$I_e \leq 17A$	6	1	0,65	6	1	0,65
	$I_e > 17A$	6	1	0,35	6	1	0,35
		I/I_e	U/U_e	L/R^b ms	I_c/I_e	U_r/U_e	L/R^b ms
DC-1	All values	1	1	1	1	1	1
DC-3	All values	2,5	1	2	2,5	1	2
DC-5	All values	2,5	1	7,5	2,5	1	7,5
I_e = rated operational current U_e = rated operational voltage I = current made In a.c. the conditions for making are expressed in r.m.s. values but it is understood that the peak value of symmetrical current corresponding to the power factor of the circuit may assume a higher value. U = applied voltage U_r = power-frequency or d.c. recovery voltage I_c = current broken ^a Tolerance for $\cos \varphi$: $\pm 0,05$ ^b Tolerance for L/R : $\pm 15\%$							

B.3.2 Results to be obtained

After the test, the contactor or the starter shall fulfil the operating conditions as specified in [9.3.6.2](#) of this standard at ambient temperature and withstand a dielectric test voltage as given in 8.3.3.4.1, item 4) b), of IEC 60947-1, and applied as in 8.3.3.4.1, item 4), of IEC 60947-1, the test voltage being applied only:

- between all poles connected together and the frame of the contactor or starter, and
- between each pole and all the other poles connected to the frame of the contactor or starter.

B.3.3 Statistical analysis of test results for contactors or starters

The electrical durability of a design of a contactor or starter is assigned by the manufacturer and verified by a statistical analysis of the results of the tests. One of the three test methods shall be selected by the manufacturer between [B.3.3.1](#), [B.3.3.2](#) and [B.3.3.3](#) as being the most suitable for example according to the quantities of planned production or according to the conventional thermal current.

For contactors or starters which are produced in small quantities, the tests described in [B.3.3.1](#) and [B.3.3.2](#) do not apply. However, for contactors or starters which are produced in small quantities and which also differ from a basic design only by minor variations without notable influence on characteristics, the manufacturer may assign electrical durability on the basis of experience with similar designs, analysis, properties of materials, etc., and on the basis of the analysis of test results on large quantity production of the same basic design.

NOTE This test is not intended to be a lot-by-lot or production acceptance test for application by the user.

B.3.3.1 Single 8 test

Eight contactors or starters shall be tested to the assigned electrical durability. If the number of failures does not exceed two, the test is considered passed.

B.3.3.2 Double 3 test

Three contactors or starters shall be tested to the assigned electrical durability. The test is considered passed if there is no failure, and failed if there is more than one failure. Should there be one failure, then three additional contactors or starters are tested up to assigned electrical durability and, providing there is no additional failure, the test is considered passed. The test is failed if at any time there is a total of two or more failures.

B.3.3.3 Other methods

Other methods given in IEC 60410 can also be used. The maximum acceptance quality level shall be 10 %. The chosen method shall be indicated in the test report.

NOTE The single 8 test and the double 3 test are both given in IEC 60410 (see Table X-C-2 and Table X-D-2). These two tests have been chosen with the objective of basing them on testing a limited number of contactors or starters on essentially the same statistical characteristics (acceptance quality level: 10 %).

B.4 Co-ordination at the crossover current between the starter and associated SCPD

B.4.1 General and definitions

B.4.1.1 General

This annex states different methods of verifying the performance of starters and the associated SCPD(s) at currents below and above the intersection I_{co} of their respective time-current characteristics, provided by the starter and SCPD manufacturer(s), and the corresponding types of co-ordination described in [8.2.5.1](#).

Co-ordination at the crossover current between the starter and the SCPD can be verified either by the direct method with the special test of [B.4.2](#) or, for type "2" co-ordination only, by the indirect method as in [B.4.5](#).

B.4.1.2 Terms and definitions

B.4.1.2.1

crossover current I_{co}

current corresponding to the crossover point of the mean or published curves representing the time-current characteristics of the overload relay and the SCPD respectively

NOTE The mean curves are the curves corresponding to the average values calculated from the tolerances on the time-current characteristics given by the manufacturer.

B.4.1.2.2**test current I_{cd}**

test current greater than I_{co} , tolerances included, designated by the manufacturer and verified by the requirements given in [Table B.2](#)

B.4.1.2.3**time-current withstand characteristic capability of contactors/starters**

locus of the currents a contactor/starter can withstand as a function of time

B.4.2 Condition for the test for the verification of co-ordination at the crossover current by a direct method

The starter and its associated SCPD shall be mounted and connected as in normal use. All the tests shall be performed starting from the cold state.

B.4.3 Test currents and test circuits

The test circuit shall be according to 8.3.3.5.2 of IEC 60947-1 except that the oscillatory transient voltage need not be adjusted. The currents for the tests shall be:

(i) $0,75 I_{co}^{-0,5} \%$ and

(ii) $1,25 I_{co}^{+5} \%$

The power factor of the test circuit shall be in accordance with [Table 7](#). In the case of small relays having a high resistance, inductors should be mainly used in order to have a value of power factor as low as possible. The recovery voltage shall be 1,05 times the rated operational voltage.

The SCPD shall be as stated in [8.2.5.1](#) and of the same rating and characteristics as used in the tests of [9.3.4.2](#).

If the switching device is a contactor, its coil shall be energized from a separate source at the rated control supply voltage of the contactor coil and connected so that the contactor opens when the overload relay operates.

B.4.4 Test procedure and results to be obtained**B.4.4.1 Test procedure**

With the starter and the SCPD closed, the test currents stated in [B.4.3](#) shall be applied by a separate closing device. In each case, the device tested shall be at room temperature.

After each test, it is necessary to inspect the SCPD, reset the overload relay and the release of the circuit-breaker, if necessary, or to replace all fuses if at least one of them has melted.

B.4.4.2 Results to be obtained

After the test at the lower current (i) in [B.4.3](#), the SCPD shall not have operated and the overload relay or release shall have operated to open the starter. There shall be no damage to the starter.

After the test at the higher current (ii) in [B.4.3](#), the SCPD shall have operated before the starter. The starter shall meet the conditions of [9.3.4.2.3](#) for the type of co-ordination stated by the manufacturer.

B.4.5 Verification of co-ordination at the crossover current by an indirect method

The indirect method consists in verifying on a diagram (see [Figure B.1](#)) that the following conditions for the verification of co-ordination at the crossover current are met:

- the time-current characteristic of the overload relay/release, starting from cold state, supplied by the manufacturer, shall indicate how the tripping time varies with the current up to a value of at least I_{co} ; this curve has to lie below the time-current characteristic of the SCPD up to I_{co} ;

- I_{cd} of the starter, tested as in [B.4.5.1](#), shall be higher than I_{co} ;

- the time-current withstand characteristic of the contactor, tested as in [B.4.5.2](#), shall be above the time-current characteristic (starting from cold state) of the overload relay up to I_{co} .

B.4.5.1 Test for I_{cd}

Subclause [9.3.4.1](#) applies with the following addition.

- Test procedure: the contactor or starter shall make and break the test current (I_{cd}) for the number of operating cycles given in [Table B.2](#) below. This is made without the SCPD in the circuit.

Table B.2
Test conditions

	U_r/U_e	$\cos \varphi$	On-time (see Note 2) s	Off-time s	Number of operations
I_{cd}	1,05	See Note 1	0,05	See Note 3	3
NOTE 1 Power factor to be selected according to Table 16 of IEC 60947-1.					
NOTE 2 Time may be less than 0,05 s provided that contacts are allowed to become properly seated before re-opening.					
NOTE 3 See Table 8 .					

- Behaviour of contactors or starters during and after the I_{cd} test:

- a) during the test, there shall be no permanent arcing, no flash-over between poles, no blowing of the fusible element in the earth circuit (see [9.3.4.1.2](#)) and no welding of contacts;

- b) after the test,

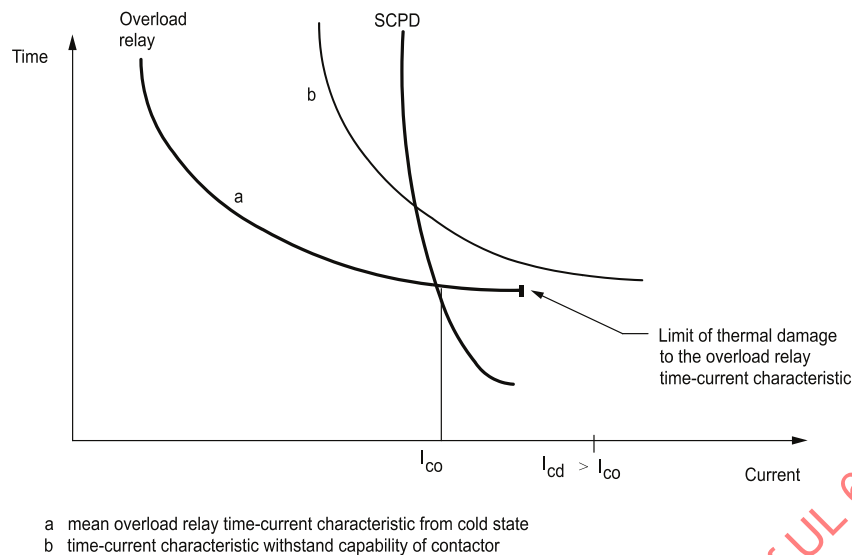
- 1) the contacts shall operate correctly when the contactor or starter is switched by the applicable method of control;

- 2) the dielectric properties of the contactors and starters shall be verified by a dielectric test on the contactor or starter using an essentially sinusoidal test voltage of twice the rated operational voltage U_e used for the I_{cd} test, with a minimum of 1 000 V. The test voltage shall be applied for 5 s, as specified in 8.3.3.4.1 of IEC 60947-1, items 2) c) i) and 2) c) ii).

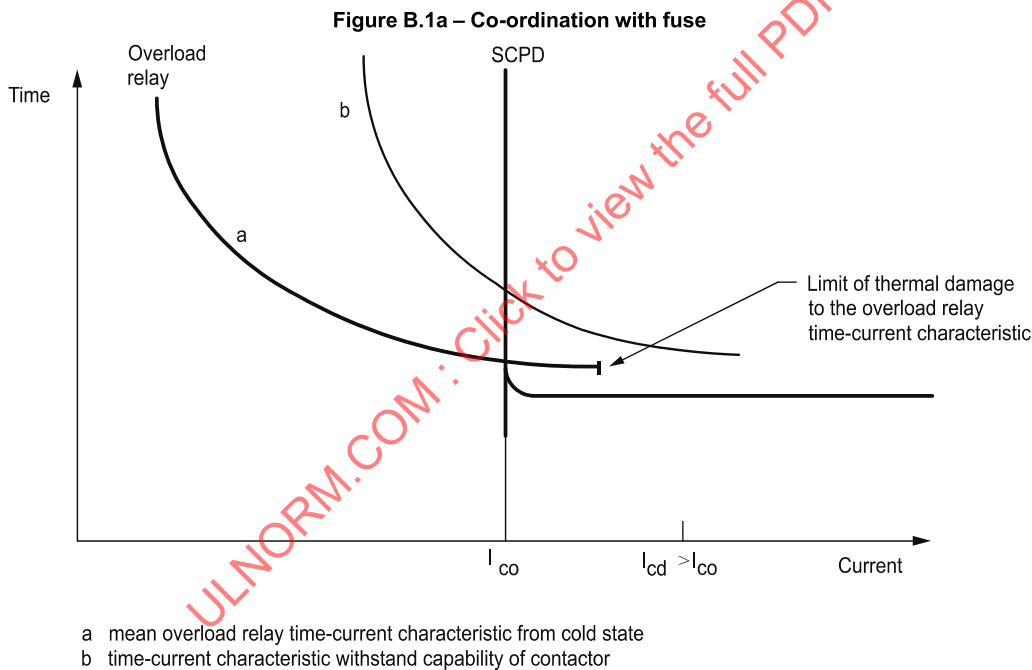
B.4.5.2 Time-current characteristic withstand capability of contactors/starters

This characteristic is issued by the manufacturer and the values are obtained according to the test procedure specified in [9.3.5](#) but with combinations of overload currents and durations to establish the characteristic at least up to I_{co} , in addition to those stated in [8.2.4.4](#).

This characteristic is valid for overload currents, starting with the contactor at room temperature. The minimum cooling duration required by the contactor between two such overload tests should be stated by the manufacturer.



su1492



su1493

Figure B.1b – Co-ordination with circuit-breaker

Figure B.1

Examples of time-current withstand characteristic

Annex C**Void**

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

Annex D (informative)

Items subject to agreement between manufacturer and user

NOTE For the purpose of this annex:

- *agreement* is used in a very wide sense;
- *user* includes testing stations.

Annex J of IEC 60947-1 applies, as far as covered by clauses and subclauses of this standard, with the following additions.

Clause or subclause number of this standard	Item
1.1.2.3	Additional requirements concerning two-direction starters and inching and plugging
5.3.4.3 – Note	Overload protection of starters for intermittent duty
5.3.5.5.3	Time interval between two successive starts of auto-transformer starters having a starting time exceeding 15 s
5.4	Types of utilization other than the utilization categories defined in Table 1
5.7.2	Specific applications of instantaneous over-current relays or releases and of relays or releases listed in 5.7.2 e)
5.7.3	Protection of the rotor circuit for a rheostatic rotor starter
5.7.3	Protection of the auto-transformer for an auto-transformer starter
5.7.5	Tolerances on time-current characteristics of overload relays (to be indicated by the manufacturer)
5.10.2	Characteristics of devices for automatic acceleration control
5.11 ; 5.12	Nature and dimensions of the connecting links: a) between an auto-transformer starter and the auto-transformer, if this is provided separately b) between a rheostatic rotor starter and the resistors, if these are provided separately Agreement for items a) and b) is to be concluded between the starter manufacturer and the manufacturer of the transformer, or of the resistors, as the case may be
8.2.2.7.3	Ratings of specially rated windings (to be stated by the manufacturer)
Table 7	Verification of the make conditions when this verification is carried out during the make and break test (manufacturer's agreement)
Table 13	Value of the prospective current " I_p " for the conditional short-circuit current test of devices of $I_e > 1\,600\text{ A}$

Annex E

(Void)

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

Annex F (normative)

Requirements for auxiliary contact linked with power contact (mirror contact)

F.1 Scope and object

F.1.1 Scope

This annex applies to auxiliary contacts mechanically linked with power contacts of a contactor and designated as mirror contacts in order to avoid any confusion with mechanically linked contact elements dealt within Annex L of IEC 60947-5-1. However, that does not prevent a given auxiliary contact to comply with both requirements for mirror contact of this annex and for mechanically linked contact of Annex L of IEC 60947-5-1.

NOTE 1 A typical application of mirror contacts is to have, in the machine control circuit, a highly reliable monitoring of the status of the contactor. However, mirror contact should not be relied upon exclusively as a means to ensure safety.

NOTE 2 Mirror contacts have previously been referred to as positively safety contacts, forced contacts, linked contacts or positively driven contacts.

NOTE 3 The meaning of "mechanically linked" is also applicable to additional contact blocks which can be mounted by the user.

F.1.2 Object

This annex provides additional specifications (definition, requirements and tests) which shall be used for stating the required design characteristics, marking and performance of mirror contact.

F.2 Terms and definitions

For the purposes of this annex, the following term and definition applies.

F.2.1

mirror contact

normally closed auxiliary contact which cannot be in closed position simultaneously with the normally open main contact under conditions defined in Clause [F.7](#).

NOTE One contactor may have more than one mirror contact.

F.3 Characteristics

All mirror contacts shall also comply with the relevant requirements given in this standard.

F.4 Product information

Clause [6](#) applies with the following addition.

Mirror contacts shall be clearly identified:

- on the contactor itself, or
- in the manufacturer documentation, or
- both.

Where a symbol is used to identify a mirror contact, it shall be as shown in [Figure F.1](#).



S5275

Figure F.1
Mirror contact

F.5 Normal service, mounting and transport conditions

There are no supplementary requirements

F.6 Constructional and performance requirements

Clause [8](#) applies with the following addition.

When any of the main contacts is closed, no mirror contact shall be closed.

NOTE Self-checking of the mirror contact circuit is recommended.

F.7 Tests

F.7.1 General

Clause [9](#) applies with the following addition.

Tests according to both [F.7.2](#) and [F.7.3](#) shall be carried out.

F.7.2 Tests on products in a new condition

For each mirror contact, the test shall be carried out on m products, where m is the number of main contacts.

A new product is used for testing each mirror contact with each of the main contacts.

The tests shall be carried out on products in a new and clean condition. The test procedure shall be as follows:

- a) To simulate the occurrence of welding on one main pole, one main contact shall be maintained in the closed position, e.g. by welding or gluing each point of contact (e.g. for double breaking contact, welding is carried out at the two contact points). The thickness of welding or gluing shall be such that the distance between contacts is not modified significantly and the method used shall be described in the test report.

b1) With the operating coil de-energized, an impulse test voltage of 2,5 kV at sea level (correction should be made according to [Table F.1](#) given below, calculated from Table 12 of IEC 60947-1) shall be applied across the mirror contact. There shall be no disruptive discharge.

Table F.1
Test voltage according to altitude

Sea level	200 m	500 m	1 000 m	2 000 m
2,5 kV	2,37 kV	2,37 kV	2,29 kV	2,12 kV
NOTE This test ensures a minimum gap of 0,5 mm in accordance with Figures A.1, Figure A.2 and Figure A.3 of IEC 60664-1 from which Table 13 of IEC 60947-1 is issued.				

b2) As an alternative to item 1) above, with the operating coil de-energized, the gap of the contact shall be measured with direct means; it shall be more than 0,5 mm. In case of two or more contact gaps in series, the sum of contact gaps shall be more than 0,5 mm.

The sequences a) and b) (1) or 2)) are repeated on new samples for each main contact welded successively.

F.7.3 Test after conventional operational performance (defined under [Table 10](#))

At the end of the conventional operational performance tests according to [9.3.3.6](#), it shall be verified that, when the coil is energized, the mirror contact shall withstand its rated insulation voltage U_i .

ULNORM.COM : Click to view the full PDF of UL 60947-4-1:22

Annex G (informative)

Rated operational currents and rated operational powers of switching devices for electrical motors

Annex GDV D2 Modification to Annex G by replacing “informative” with “normative”:

Annex G is normative.

G.1 General

The given values in [Table G.1](#) are guide values for the relationship between rated operational currents and rated operational powers. They should be considered for use when information concerning products has to be given to the customers.

The statements of this annex are applicable to all kind of switching devices for electrical motors.

The figures are harmonized within the IEC and therefore state the basis for all the product information given by the manufacturer.

The values given in the [Table G.1](#) are typical rated operational currents of motors for the corresponding rated operational powers.

If the devices are in compliance with these values, they are able to switch on and off most of the existing electrical motors.

These values state a harmonized guideline for design of switching devices.

G.1DV D2 Modification to G.1 by adding the following:

The rated operational currents corresponding to horsepower ratings shall be in accordance with Tables 430.247 through 430.251 of NFPA 70 or Tables 44 and 45 of CSA C22.1.

G.2 Rated operational powers and rated operational currents

Rated operational power is linked with individual rated operational currents at different voltages according to [Table G.1](#).

The guide values for rated operational currents are determined on the basis of a four-pole squirrel-cage motor at 400 V, 1 500 min⁻¹ and 50 Hz. The rated operational currents for the other voltages are calculated on the basis of values at 400 V.

Table G.1
Rated operational powers and rated operational currents of motors

Rated operational power kW ^a hp ^b		Guide values of rated operational currents at										
		110 – 120 V A	200 V A	208 V A	230 V A	220-240 V A	380-415 V A	400 V A	440-480 V A	500 V A	550-600 V A	690 V A
0,06	–	–	–	–	0,35	–	–	0,20	–	0,16	–	0,12
0,09	–	–	–	–	0,52	–	–	0,30	–	0,24	–	0,17
0,12	–	–	–	–	0,70	–	–	0,44	–	0,32	–	0,23
0,18	–	–	–	–	1,0	–	–	0,60	–	0,48	–	0,35
0,25	–	–	–	–	1,5	–	–	0,85	–	0,68	–	0,49
0,37	–	–	–	–	1,9	–	–	1,10	–	0,88	–	0,64
–	1/2	4,4	2,5	2,4	–	2,2	1,3	–	1,1	–	0,9	–
0,55	–	–	–	–	2,6	–	–	1,5	–	1,2	–	0,87
–	3/4	6,4	3,7	3,5	–	3,2	1,8	–	1,6	–	1,3	–
–	1	8,4	4,8	4,6	–	4,2	2,3	–	2,1	–	1,7	–
0,75	–	–	–	–	3,3	–	–	1,9	–	1,5	–	1,1
1,1	–	–	–	–	4,7	–	–	2,7	–	2,2	–	1,6
–	1-1/2	12,0	6,9	6,6	–	6,0	3,3	–	3,0	–	2,4	–
–	2	13,6	7,8	7,5	–	6,8	4,3	–	3,4	–	2,7	–
1,5	–	–	–	–	6,3	–	–	3,6	–	2,9	–	2,1
2,2	–	–	–	–	8,5	–	–	4,9	–	3,9	–	2,8
–	3	19,2	11,0	10,6	–	9,6	6,1	–	4,8	–	3,9	–
3,0	–	–	–	–	11,3	–	–	6,5	–	5,2	–	3,8
4	–	–	–	–	15	–	–	8,5	–	6,8	–	4,9
–	5	30,4	17,5	16,7	–	15,2	9,7	–	7,6	–	6,1	–
5,5	–	–	–	–	20	–	–	11,5	–	9,2	–	6,7
–	7-1/2	44,0	25,3	24,2	–	22,0	14,0	–	11,0	–	9,0	–
–	10	56,0	32,2	30,8	–	28,0	18,0	–	14,0	–	11,0	–
7,5	–	–	–	–	27	–	–	15,5	–	12,4	–	8,9
11	–	–	–	–	38,0	–	–	22,0	–	17,6	–	12,8
–	15	84	48,3	46,2	–	42,0	27,0	–	21,0	–	17,0	–
–	20	108	62,1	59,4	–	54,0	34,0	–	27,0	–	22,0	–
15	–	–	–	–	51	–	–	29	–	23	–	17

Table G.1 Continued on Next Page

Table G.1 Continued

Rated operational power kW ^a hp ^b		Guide values of rated operational currents at										
		110 – 120 V A	200 V A	208 V A	230 V A	220-240 V A	380-415 V A	400 V A	440-480 V A	500 V A	550-600 V A	690 V A
18,5	–	–	–	–	61	–	–	35	–	28	–	21
–	25	136	78,2	74,8	–	68	44	–	34	–	27	–
22	–	–	–	–	72	–	–	41	–	33	–	24
–	30	160	92	88	–	80	51	–	40	–	32	–
–	40	208	120	114	–	104	66	–	52	–	41	–
30	–	–	–	–	96	–	–	55	–	44	–	32
37	–	–	–	–	115	–	–	66	–	53	–	39
–	50	260	150	143	–	130	83	–	65	–	52	–
–	60	–	177	169	–	154	103	–	77	–	62	–
45	–	–	–	–	140	–	–	80	–	64	–	47
55	–	–	–	–	169	–	–	97	–	78	–	57
–	75	–	221	211	–	192	128	–	96	–	77	–
–	100	–	285	273	–	248	165	–	124	–	99	–
75	–	–	–	–	230	–	–	132	–	106	–	77
90	–	–	–	–	278	–	–	160	–	128	–	93
–	125	–	359	343	–	312	208	–	156	–	125	–
110	–	–	–	–	340	–	–	195	–	156	–	113
–	150	–	414	396	–	360	240	–	180	–	144	–
132	–	–	–	–	400	–	–	230	–	184	–	134
–	200	–	552	528	–	480	320	–	240	–	192	–
150	–	–	–	–	–	–	–	–	–	–	–	–
160	–	–	–	–	487	–	–	280	–	224	–	162
185	–	–	–	–	–	–	–	–	–	–	–	–
–	250	–	–	–	–	604	403	–	302	–	242	–
200	–	–	–	–	609	–	–	350	–	280	–	203
220	–	–	–	–	–	–	–	–	–	–	–	–
–	300	–	–	–	–	722	482	–	361	–	289	–
250	–	–	–	–	748	–	–	430	–	344	–	250
280	–	–	–	–	–	–	–	–	–	–	–	–
–	350	–	–	–	–	828	560	–	414	–	336	–
–	400	–	–	–	–	954	636	–	477	–	382	–

Table G.1 Continued on Next Page

Table G.1 Continued

Rated operational power kW ^a hp ^b		Guide values of rated operational currents at										
		110 – 120 V A	200 V A	208 V A	230 V A	220-240 V A	380-415 V A	400 V A	440-480 V A	500 V A	550-600 V A	690 V A
300	–	–	–	–	–	–	–	–	–	–	–	–
315	–	–	–	–	940	–	–	540	–	432	–	313
–	450	–	–	–	–	1 030	–	–	515	–	412	–
335	–	–	–	–	–	–	–	–	–	–	–	–
355	–	–	–	–	1 061	–	–	610	–	488	–	354
–	500	–	–	–	–	1 180	786	–	590	–	472	–
375	–	–	–	–	–	–	–	–	–	–	–	–
400	–	–	–	–	1 200	–	–	690	–	552	–	400
425	–	–	–	–	–	–	–	–	–	–	–	–
450	–	–	–	–	–	–	–	–	–	–	–	–
475	–	–	–	–	–	–	–	–	–	–	–	–
500	–	–	–	–	1 478	–	–	850	–	680	–	493
530	–	–	–	–	–	–	–	–	–	–	–	–
560	–	–	–	–	1 652	–	–	950	–	760	–	551
600	–	–	–	–	–	–	–	–	–	–	–	–
630	–	–	–	–	1 844	–	–	1 060	–	848	–	615
670	–	–	–	–	–	–	–	–	–	–	–	–
710	–	–	–	–	2 070	–	–	1 190	–	952	–	690
750	–	–	–	–	–	–	–	–	–	–	–	–
800	–	–	–	–	2 340	–	–	1 346	–	1 076	–	780
850	–	–	–	–	–	–	–	–	–	–	–	–
900	–	–	–	–	2 640	–	–	1 518	–	1 214	–	880
950	–	–	–	–	–	–	–	–	–	–	–	–
1 000	–	–	–	–	2 910	–	–	1 673	–	1 339	–	970

^a Preferred rated values according to IEC 60072-1 (primary series).

^b Horsepower and currents values according to UL 508 (60 Hz).

Annex H (normative)

Extended functions to electronic overload relays

H.1 General

Annex T of IEC 60947-1:2007, Amendment 1 applies with the following additions.

H.2 Terms and definitions

H.2.1

electronic overload relay with control functions

multipole electronic relay with motor control operations through its inputs and outputs

NOTE Example of control functions: reversing control, two speed control, star-delta control, etc.

H.2.2

electronic overload relay with under-voltage restarting function

electronic relay which operates when the voltage applied to the main circuit or control circuit is reduced below a predetermined value and automatically resets (with or without time delay) when the voltage is recovered

H.2.3

electronic overload relay with main circuit under-voltage restarting function

electronic overload relay with under-voltage restarting function monitoring only the main circuit

H.2.4

electronic overload relay with control circuit under-voltage restarting function

electronic overload relay with under-voltage restarting function monitoring only the control circuit

NOTE The automatic restarting function may be de-activated.

H.3 Limits of operation of control functions

H.3.1 General

The operation time sequences, the interactions with the inputs and outputs and the limits of operation shall be described in the manufacturer literature.

For motor restart functions, the ranges and tolerances of time and voltage dip detection and of the delay of restarting after voltage restoration shall be given in the manufacturer literature.

H.3.2 Limits of electronic overload relay with main circuit under-voltage restarting function

When under-voltage or loss of voltage occurs in the main circuit, the relay will operate. The following applies:

- a) if the voltage resumes within T1 (off-time for immediate reset), the overload relay shall control the starter circuit to immediately restore the running condition;
- b) if the voltage resumes between T1 and T2 (off-time for reset), the relay shall reset to the starting sequence;
- c) if the voltage resumes after T2, the relay shall not reset automatically.

T1 and T2 are adjustable, and the value of T2 is greater than T1.

The tolerance of the threshold voltage and of the time settings shall be specified by the manufacturer but no more than $\pm 10\%$. If the time setting value is lower than 1 s, the manufacturer shall state the tolerances.

H.4 Test of the control functions

The test of the control functions shall be verified according to [H.3](#), and each control function should be verified at least 3 times.

For restart functions, the detection time for a voltage dip and the delay of restarting shall be verified according to [H.3](#).

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

Annex I (informative)

AC1 contactors for use with semiconductor controlled motor loads

Contactors are often used with semiconductor controllers, starters or drives. Contactors for such applications are not intended to make or break motor load currents at the stated system voltage.

The intended use is to carry motor currents either on the line or load side of such controllers, and allow the controller to be removed from the line and/or load in the off condition. A further use is to by-pass controllers, usually for the purpose of reducing thermal losses, in the up-to speed condition. In such applications the contactors should be so controlled and interlocked so as to prevent them being opened or closed when the load current is present.

When the above conditions are met, the contactors may be chosen according to category AC1.

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022

Annex J

Void

ULNORM.COM : Click to view the full PDF of UL 60947-4-1 2022