

IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations

IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
U.S.A.

IEEE Std 1349™-2011
(Revision of
IEEE Std 1349-2001)

9 December 2011

Currently in preview, click buy full version

IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations

Sponsor

Petroleum and Chemical Industry Committee
of the
IEEE Industry Applications Society

Approved 10 September 2011

IEEE-SA Standards Board

Credits

Grateful acknowledgment is made to the following organizations for granting permission to reprint excerpts, figures, and tables in this guide:

Excerpts reprinted with permission from NFPA 70[®]-2011, National Electrical Code[®], Copyright © 2011, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the reference subject that is represented only by the standard in its entirety.

Excerpts reprinted with permission from NFPA 497 *Recommended Practice for Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, Copyright © 2008, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the reference subject, which is represented only by the standard in its entirety.

Figures 2, 4, 5, 6, 8, G.1, and G.2 Courtesy of General Electric.

Figure 3, Courtesy of Marathon Electric.

Figure 7, Courtesy of Teco Westinghouse Motor Company.

Table C.2, Reprinted with permission from NFPA 70[®]-2011, National Electrical Code[®], Copyright © 2011, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the reference subject which is represented only by the standard in its entirety.

Tables H.1 and H.2 from Hamer, P. S., Wood, B. M., Doughty, R. L., Grivell, R. L., Hasty, R. C., Wallace, S. E., and Tsao, J. P., "Flammable vapor ignition initiated by hot rotor surfaces within an induction motor—reality or not? *PCIC Conference Record*, pp. 37–47, 1997, Copyright © 1997 IEEE.

Abstract: Three-phase and single-phase AC synchronous and induction electric motors in ratings 0.18 kW (1/4 hp) and larger are covered in this guide. Primary emphasis is on the use of open or nonexplosionproof or nonflameproof enclosed motors in Class I, Division 2 and Class I, Zone 2 locations as covered in NFPA 70-2011. Surface temperature test methods and sine wave and non-sine wave applications are covered. Precautions against excessive surface temperatures and sparking are included. To mitigate hot surface temperatures and sparking, this document provides guidance for selecting, operating, and maintaining motors in Class I, Division 2 and Class I, Zone 2 locations. This guide does not cover AC wound rotor motors and DC electric motors. Motors installed in locations other than Class I, Division 2 and Class I, Zone 2 as covered in NFPA 70-2011 are not covered in this guide. This document is not a specification and is not intended to be used as a specification for purchasing motors. The voltage breaks in this document are 1000 V and less, and over 1000 V.

Keywords: adjustable speed drive; autoignition temperature; Class I, Division 2; Class I, Zone 2; classified locations; enclosure sparking; hazardous locations; IEEE 1349; induction motor; paint test; motor; motor enclosure; motor temperature; multisection motor; paint test; rotor; rotor sparking; rotor temperature; synchronous motor; T Code; temperature code

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2011 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 9 December 2011. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

NFPA 70®, National Electrical Code®, and NEC® are registered trademarks of the National Fire Protection Association, Quincy, MA.

PDF: ISBN 978-0-7381-6803-6 STD97163
Print: ISBN 978-0-7381-6804-3 STDPD97163

IEEE prohibits discrimination, harassment and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html>.
No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "AS IS."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretation is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretation, should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854
USA

Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

This introduction is not part of IEEE Std 1349-2011, IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations.

This guide was developed to assist individuals, organizations, and suppliers with the application of motors in Class I, Division 2 and Class I, Zone 2 locations, where flammable gases and vapors may occasionally be present.

Notice to users

Laws and regulations

Users of these documents should consult all applicable laws and regulations. Compliance with the provisions of this standard does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

This document is copyrighted by the IEEE. It is made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making this document available for use and adoption by public authorities and private users, the IEEE does not waive any rights in copyright to this document.

Updating of IEEE documents

Users of IEEE standards should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE Standards Association web site at <http://ieeexplore.ieee.org/xpl/standards.jsp>, or contact the IEEE at the address listed previously.

For more information about the IEEE Standards Association or the IEEE standards development process, visit the IEEE-SA web site at <http://standards.ieee.org>.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/findstds/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/findstds/interps/index.html>.

Patents

Attention is called to the possibility that implementation of this guide may require use of subject matter covered by patent rights. By publication of this guide, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patent Claims or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this guide are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this guide was submitted to the IEEE-SA Standards Board for approval, the Motors in Hazardous Locations Working Group had the following membership:

Lorraine K. Padden, *Chair*

Paul Anderson, *Vice Chair*

Frederick Bried, *Secretary*

Charlie Boynton
Gabe F. D'Alleva
Daniel Delaney
John Travis Griffith
Royce M. King
William Lockley
Bharat Mistry

Rajendra Mistry
Daleep C. Mohla
Art Neubauer
Joel Northwall
Rick Paes
Javier Portos
David Rains
John Rama

John Rydeski
Tom Stewart
Sandra Strickland
Kevin Taylor
Wayne Wasserman
Barry M. Wood
Ther Xiong

The following individuals contributed to the development of this guide, but were not Working Group members at the time this guide was completed:

Austin Bonnett
Richard Doughty*
Jim Dymond
Carl J. Fredericks
Shan Griffith
Steve Hamilton

Ralph Haynes **
Mark Hodowanec
Richard Holub
Bob Keough
William Magerkurth
Robbie McElveen

John Malinowski
Hein Pham
M. P. Reddy
Chuck Straub
Mike Toney

* Past Co-Chair IEEE 1349

** Past Chair IEEE 1349

The following members of the individual balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

Gabe F. D'Alleva
Paul Anderson
Michael Bayer
Thomas Bishop
Frederick Bried
William Byrd
Weijen Chen
Roger Daugherty
Glenn Davis
Gary Donner
Donald Dunn
Jim Dymond
William Finley
Carl F. Fredericks
Manjinder Gill
Randall Groves
Paul Hamer
Jung-Yu Han

Lee Herron
Scott Hietpas
Richard Holub
Richard C. Hulett
Yuri Khersonsky
Royce M. King
Jim Kulchisky
William Lawrence
Duane Leschert
William Lockley
Greg Luri
John Malinowski
William McBride
Bharat Mistry
Daleep C. Mohla
Paul Myers
Art Neubauer
Michael S. Newman
Lorraine K. Padden

Rick Paes
Howard Penrose
Christopher Petrola
Julian Profir
John Rama
Estellito Rangel, Jr.
M. P. Reddy
Bartien Sayogo
Robert Seitz
Gil Shultz
James Smith
Jeremy Smith
Gary Stoedter
Gregory Stone
John Vergis
Kenneth White
Barry M. Wood
Donald Z...

When the IEEE-SA Standards Board approved this standard on 10 September 2011, it had the following membership:

Richard H. Hulett, *Chair*
John Kulick, *Vice Chair*
Robert M. Grow, *Past Chair*
Judith Gorman, *Secretary*

Masayuki Ariyoshi
William Bartley
Ted Burse
Clint Chaplin
Wael Diab
Jean-Philippe Faure
Alex Gelman
Paul Houzé

Jim Hughes
Joseph L. Koepfinger*
David Law
Thomas Lee
Hung Ling
Oleg Logvinov
Ted Olsen

Gary Robinson
Jon Rosdahl
Sam Sciacca
Mike Seavey
Curtis Siller
Phil Winston
Howard Wolfman
Don Wright

* Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Catherine Berger
IEEE Standards Project Editor

Patricia Gerdon
IEEE Standards Program Manager, Technical Program Development

Contents

1. Overview	1
1.1 Scope	2
1.2 Purpose	2
1.3 Background.....	2
1.4 Industry experience.....	3
2. Normative references.....	3
3. Definitions, acronyms, and abbreviations	4
3.1 Definitions	4
3.2 Acronyms and abbreviations	8
4. Phenomenon of a motor as a possible ignition source.....	9
4.1 Ignition overview.....	10
4.2 Ignition components	10
4.3 Gas AIT and group designation.....	11
4.4 Gas ingress.....	11
5. Common applications.....	13
5.1 Common application conditions	14
5.2 Surface temperatures	15
5.3 Sparking.....	15
5.4 General equipment considerations.....	15
5.5 Application considerations for motors 1000 V and below.....	19
5.6 Application considerations for motors above 1000 V	20
5.7 Application considerations for synchronous motors.....	23
6. Uncommon application considerations.....	26
6.1 High or low ambient temperature	26
6.2 High altitudes.....	26
6.3 Nonsinusoidal power or adjustable speed operations	27
6.4 Duty cycle other than continuous	30
6.5 Excessive starts.....	30
6.6 High inertia load	30
6.7 NEMA Design C or D and low inrush motors.....	31
6.8 Voltage and frequency variation.....	31
6.9 Overload	32
6.10 Atmospheres with an AIT at or less than those of Table 1	33
6.11 Motor exposed surface temperature above Table 1 values or above Class B rise	33
6.12 Other considerations	34
7. Operation and maintenance considerations	35
7.1 Commissioning considerations	35
7.2 Maintenance considerations.....	36
8. Preferred motor internal surface temperature test methods	37
8.1 Preferred motor rotor surface temperature test methods.....	38
8.2 Motor surface temperature test procedures.....	38
Annex A (informative) Bibliography	44

Annex B (informative) Regulations and standards for motors used in areas where flammable gases or vapors may be present	48
B.1 Occupational Safety and Health Administration (OSHA)	48
B.2 National Fire Protection Association	48
B.3 American Petroleum Institute	49
B.4 International standards	49
Annex C (informative) AIT and group designations for Class I materials	51
C.1 AITs	51
Annex D (informative) Motor enclosure types and protection techniques	56
D.1 Open motor (IP00, IC01)	57
D.2 Totally enclosed motor	58
D.3 Zone protection methods	59
Annex E (informative) Motor information tables.....	63
Annex F (informative) Multisection motor inspection procedure	67
Annex G (informative) Motor sparking considerations.....	68
G.1 General.....	68
G.2 Motors over 1000 V.....	69
G.3 Sparking across bearing lubrication due to CMV	72
Annex H (informative) Surface temperature study results and considerations.....	75
H.1 Hot motor surfaces.....	75
H.2 Surface temperature study results	76
H.3 Temperature test observations	102
Annex I (informative) Motor surface temperature test methods and limitations.....	105
I.1 Infrared method	105
I.2 Thermocouples placed in the air gap.....	106
I.3 Hot versus cold slip	106
I.4 Stator thermocouples.....	107
I.5 Thermodynamic computer model.....	107
Annex J (informative) Event history	108

IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations

IMPORTANT NOTICE: This standard is not intended to ensure safety, security, health, or environmental protection. Implementers of the standard are responsible for determining appropriate safety, security, environmental, and health practices or regulatory requirements.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Documents.” They can also be obtained on request from IEEE or viewed at <http://standards.ieee.org/IPR/disclaimers.html>.

1. Overview

This guide is divided into several clauses. Clause 1 provides the scope of this guide. Clause 2 lists references to other standards that are inclusive when applying this guide. Clause 3 provides definitions, abbreviations, and acronyms that are either not found in other standards, or have been modified for use with this guide. Clause 4 describes the phenomenon of a motor as a possible ignition source. Clause 5 provides guidance for Common applications of motors in Class I, Division 2 and Class I, Zone 2 locations. Consideration should be given to the maximum recommended Class I, Division 2 or Zone 2 exposed motor surface temperatures described in 5.2 for Common applications. Clause 6 provides guidance for Uncommon applications of motors in Class I, Division 2 and Class I, Zone 2 locations. Clause 7 discusses the operating and maintenance considerations that mitigate hot surface temperatures and sparking, specifically focusing on motors located in Class I, Division 2 or Zone 2 locations. Clause 8 describes preferred test methods for determining internal motor surface temperatures for the purpose of applying motors in Class I, Division 2 and Class I, Zone 2 locations.

Ten annexes are included: A) bibliography, B) regulations and standards for motors used in areas where flammable gases or vapors may be present, C) AITs (autoignition temperature) and group designations for Class I materials, D) motor enclosure types and protection techniques, E) motor information tables to check a motor data sheet, F) multisection motor inspection procedure, G) motor sparking considerations, H) surface temperature study results and considerations, I) motor surface temperature test methods and limitations, and J) event history.

1.1 Scope

Three-phase and single-phase AC synchronous and induction electric motors in ratings 0.18 kW (1/4 hp) and larger are covered in this guide. Primary emphasis is on the use of open or nonexplosionproof or nonflameproof enclosed motors in Class I, Division 2 and Class I, Zone 2 locations as covered in *National Electrical Code*[®] (*NEC*[®]) (NFPA 70-2011).¹ Surface temperature test methods and sine wave and non-sine wave applications are covered. Precautions against excessive surface temperatures and sparking are included. To mitigate hot surface temperatures and sparking, this document provides guidance for selecting, operating, and maintaining motors in Class I, Division 2 and Class I, Zone 2 locations. This guide does not cover AC wound rotor motors and DC electric motors. Motors installed in locations other than Class I, Division 2 and Class I, Zone 2 as covered in NFPA 70-2011 are not covered in this guide. This document is not a specification and is not intended to be used as a specification for purchasing motors.

The voltage breaks in this document are 1000 V and less, and over 1000 V.

1.2 Purpose

Existing codes and standards contain cautionary notes for open or nonexplosionproof or nonflameproof enclosed motors in Class I, Division 2 and Class I, Zone 2 locations as covered in the *NEC*. This guide documents industry experience and established practices and provides guidance for applying motors in these locations.

1.3 Background

As early as 1905, the *National Electrical Code*[®] (*NEC*[®])² recognized that a suitable enclosure would be required when an electric motor was installed in the vicinity of combustible materials (*National Electric Code*, 1905) [B54].³ In the early 1920s, the *NEC* began to designate and recognize flammable and combustible materials by the current Class system without Division subcategories. With this system, an electric motor located within a Class I location was required to have an explosionproof enclosure.

In 1931, Classes were introduced to the *NEC*; in 1935, Groups A, B, C, and D were added; and in 1947, Divisions 1 and 2 were added. By allowing a Division 2 location to be individually evaluated on the basis of the amount of material that may escape during abnormal operating conditions, adequacy of ventilation, total area involved, and the history of the type of installation, the *NEC* allowed open-type, nonexplosionproof electric motors to be installed in Division 2 locations. During this same period, electric motor manufacturers also developed the totally enclosed, fan cooled (TEFC) motor. By 1947, the *NEC* permitted open-type and TEFC motors “without brushes, switching mechanisms or integral resistance devices” for installation in Division 2 locations. From that time until the mid-1980s, hundreds of thousands of open-type and TEFC motors, ranging in size from fractional horsepower to over 10000 hp, had been installed in Class I, Division 2 locations.

This guide addresses two Informational Notes for Division applications: Fine Print Note (FPN) No. 1 was added to the *NEC* in 1984 to Section 501 and currently is in Section 501.125(B) Informational Note No. 1 as follows: “It is important to consider the temperature of internal and external surfaces that may be exposed to the flammable atmosphere.”⁴ FPN No. 2 was added to the *NEC* in 1993 to Section 501 and

¹ Information on references can be found in Clause 2.

² NFPA 70[®], National Electrical Code[®], and NEC[®] are registered trademarks of the National Fire Protection Association, Quincy, MA.

³ The numbers in brackets correspond to those of the bibliography in Annex A.

⁴ Reprinted with permission from NFPA 70[®]-2011, National Electrical Code[®] Copyright © 2010, National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official position of the NFPA on the reference subject which is represented only by the standard in its entirety.