

IEEE Standard for the Repair and Rewinding of AC Electric Motors in the Petroleum, Chemical, and Process Industries

IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee



IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1068™-2015
(Revision of
IEEE Std 1068-2009)

IEEE Standard for the Repair and Rewinding of AC Electric Motors in the Petroleum, Chemical, and Process Industries

Sponsor

Petroleum and Chemical Industry Committee
of the
IEEE Industry Applications Society

Approved 5 December 2015

IEEE-SA Standards Board

**This is a Redline document produced by Techstreet,
a business of Thomson Reuters.**

Redlines are designed to save time and improve productivity by using the latest software technology to find and highlight document changes from one edition to the next. It includes a full-text version of the new document, plus an indication of changes from the previous version.

Because it may not be technically possible to capture all changes accurately, it is recommended that users consult previous editions as appropriate. In all cases, only the current base version of this publication is to be considered the official document. This Redline is produced solely by Techstreet. The publisher has not prepared this Redline and is not responsible for its accuracy.

To obtain previous editions or additional copies of this document, please visit www.techstreet.com, or call Techstreet at +1 800 699 9277 or +1 734 780 8000.

**Thomson Reuters
Techstreet**

6300 Interfirst Drive
Ann Arbor, MI 48108 USA

Phone: +1 734 780 8000
Toll Free: +1 800 699 9277
Fax: +1 734 780 2046

techstreet.service@thomsonreuters.com
techstreet.com



Redline Processing Notes:

1. ~~Red Text~~ - Red strikethrough text denotes deletions.
2. Blue Text - Blue underlined text denotes modifications and additions.

Abstract: This standard is intended to be a basic or primary document that can be utilized and referenced by owners of ac motors and generators (machines) that need refurbishment, repair, and/or rewinding, as well as service or repair facilities. It has been developed for the petroleum, chemical, and process industries, and it may be adapted to other areas of interest. The use of this standard is expected to result in higher quality and more cost-effective, timely repairs. A means of evaluating work performed and repair or service facilities is also provided.

Keywords: ac generator, ac machine, ac motor, IEEE 1068™, induction, refurbish, repair, repair facility, rewind, service facility, synchronous

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

Copyright © 2016 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 15 January 2016. 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.

PDF: ISBN 978-1-5044-0103-6 STD20512
Print: ISBN 978-1-5044-0104-3 STDPD20512

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.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading “Important Notice” or “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (“IEEE-SA”) Standards Board. IEEE (“the Institute”) develops its standards through a consensus development process, approved by the American National Standards Institute (“ANSI”), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, 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.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

Use of an IEEE standard is wholly voluntary. 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.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own 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.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of 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 of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive 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 comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

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

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document 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

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted 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 these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, 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.

Updating of IEEE Standards documents

Users of IEEE Standards documents 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.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, 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 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-SA Website at <http://ieeexplore.ieee.org/xpl/standards.jsp> or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at <http://standards.ieee.org>.

Errata

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

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at <http://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. 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 Patents 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 standard 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 IEEE standard was completed, the Repair and Rewinding of Electric Motors Working Group had the following membership:

Charles “Chuck” Yung, *Chair*
William Lockley, *Vice Chair*
Javier Portos, *Secretary*

Dale Basso
Dennis Bogh
Austin Bonnett

J. Travis Griffith
Saeed Haq

Bryan Klontz
Tom Stewart
Mark Zawadski

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

Emmanuel Agamloh
Gabriele F. D. Alleva
Dale Basso
Thomas Bishop
Thomas Blair
William Bloethe
James Bryan
Paul Cardinal
Wei-jen Chen
Keith Chow
Glenn Davis
Davide De Luca
Gary Donner
Donald Dunn
Robert Durham
James Dymond
William Finley

Carl Fredericks
J. Travis Griffith
Randall Groves
Paul Hamer
Chris Heron
Lee Herron
Scott Hietpas
Werner Hoelzl
Richard Holub
Richard Hulett
Shahid Jamil
Yuri Khersonsky
Royce King
William Lockley
John McAlhaney, Jr.
William McBride
Bharat Mistry
Daleep Mohla

Paul Myers
Dennis Neitzel
Arthur Neubauer
Michael Newman
Lorraine Padden
Christopher Petrola
Iulian Profir
Bartien Sayogo
Nikunj Shah
Jerry Smith
Gregory Stone
Edward Thornton
Wayne Timm
Kenneth White
Roger Wicks
Charles “Chuck” Yung
Hugh Zhu

When the IEEE-SA Standards Board approved this standard on 5 December 2015, it had the following membership:

John D. Kulick, *Chair*
Jon Walter Rosdahl, *Vice Chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Masayuki Ariyoshi
Ted Burse
Stephen Dukes
Jean-Philippe Faure
J. Travis Griffith
Gary Hoffman
Michael Janezic

Joseph L. Koepfinger*
David J. Law
Hung Ling
Andrew Myles
T. W. Olsen
Glenn Parsons
Ronald C. Petersen
Annette D. Reilly

Stephen J. Shellhammer
Adrian P. Stephens
Yatin Trivedi
Philip Winston
Don Wright
Yu Yuan
Daidi Zhong

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 1068™-2015, IEEE Standard for the Repair and Rewinding of AC Electric Motors in the Petroleum, Chemical, and Process Industries.

This document was originally published in 1990 and was revised in 1996. In keeping with the goals of maintaining progressive standards, in 2002 the Standards Subcommittee of the IEEE Petroleum and Chemical Industry Committee assigned a task force to revise and update this standard. References to other documents have been corrected. The wording in this standard was modified to reflect worldwide standards and to promote uniform application of such devices in petroleum and chemical industry facilities.

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	2
2. Normative references	2
3. Definitions	4
4. Responsibilities	5
4.1 User responsibility	6
4.2 Repair facility responsibility	8
5. Preliminary assessment	8
5.1 Initial receipt	8
5.2 Incoming tests	10
5.3 Initial run check	11
6. Condition and damage appraisal	13
6.1 Component marking and evaluation	13
6.2 Detailed mechanical evaluation	16
6.3 Detailed electrical evaluation	23
6.4 Other	29
7. Cleaning and reconditioning	29
7.1 General	29
7.2 Reconditioning of flooded motors	30
8. Facility repair or refurbishment period	31
8.1 Receiving	31
8.2 Stripping	31
8.3 Stator and rotor lamination evaluation	32
8.4 Description of winding types	33
8.5 Replacement of coils	34
8.6 Bearing replacement and restoration of rotational fits and seals	45
8.7 Balancing	48
8.8 Electrical connections	49
8.9 Mechanical fits	50
8.10 Painting	51
8.11 Permanent magnet rotors	51
8.12 Miscellaneous	52
8.13 Final test	53
8.14 Shipping precautions	55
9. Field repairs	55
10. Post repair	55
10.1 Repair facility	55
10.2 User handling	55
Annex A (informative) Bibliography	57

Annex B (informative) Typical repair facility evaluation form.....	59
Annex C (informative) In-plant motor evaluation.....	69
Annex D (normative) Motor repair form (to be completed by owner).....	71
Annex E (normative) Condition report forms	73
Annex F (informative) Magnetic wedges	77
Annex G (informative) Repair checklist.....	78
G.1 Checklist	78
G.2 Final test results	79

IEEE Standard for the Repair and Rewinding of AC Electric Motors in the Petroleum, Chemical, and Process Industries

IMPORTANT NOTICE: ~~This standard~~ IEEE Standards ~~is~~ documents are not intended to ensure safety, security, health, or environmental protection, ~~in all circumstances~~ or ensure against interference with or from other devices or networks. Implementers of ~~the~~ IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices ~~or regulatory requirements~~ and all applicable laws and regulations.

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

1.1 Scope

This document covers general recommendations for the repair of alternating current (ac) electric motors and includes guidelines for both the user and the repair facility. It is not intended to replace specific instructions contained in the manufacturer's instruction book or in any contractual agreement between a manufacturer and a purchaser of a given machine. For the purpose of this document, the term *motor* is used in lieu of, and shall equate to, the terms *wound rotor*, *generator*, and *machine*.

This standard covers reconditioning, repair, and rewind of horizontal and vertical induction motors and of synchronous motors. It applies to all voltages 15 kV and less, and all ratings above 0.75 kW (1 hp).

This standard applies only to the repair of motors, and in cases involving modifications to the basic design, care must be taken so as not to negatively affect the safety and reliability of the motor.

Excluded from the scope of this standard are the following:

- Specific requirements, certification, and inspection required for explosion proof, dust-ignition proof, flameproof, and like motors having a listing issued by a Nationally Recognized Testing

Laboratory (NRTL), for example, [American Bureau of Shipping \(ABS\)](#), Underwriters Laboratories, Inc. (UL), Factory Mutual (FM), and Canadian Standards Association (CSA). For motors in this category, the user shall verify if the repair facility shall be certified by such an agency.

- Any specific or additional requirements for hermetic motors, hydrogen-cooled generators, submersible motors, or Class 1E nuclear service motors.
- Direct current (dc) motors.

1.2 Purpose

This standard is intended to be used and referenced by users of motors that need repair as well as by owners and operators of establishments that offer motor repair services. It has been developed primarily for the needs of the petroleum, chemical, and process industries, but can be adapted to other applications or industries.

The use of this standard by users and repair facilities is expected to result in higher quality, cost-effective, timely repairs. It also provides a means of evaluating repairs and facilities.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI/ABMA 20-~~1996~~, Radial Bearings of Ball, Cylindrical Roller and Spherical Roller Types—Metric Design.^{1, 2}

¹ ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

² ABMA publications are available from the American Bearing Manufacturers Association (ABMA), 2025 M Street, NW, Suite 800, Washington, DC 20036 (<http://www.abma-dc.org/>).

API 541-~~2003~~, Form-Wound Squirrel-Cage Induction Motors—500 Horsepower and Larger.³

[API 541-2014 \(6.3.3.13, Annex D, Annex E\), Form-Wound Squirrel-Cage Induction Motors—500 Horsepower and Larger.](#)

API 546-~~1997~~, Brushless Synchronous Machines—500 KVA and Larger.

[API 546-2008 \(2.4.6.3, 4.3.3.11, Annex F, Annex G\) Brushless Synchronous Machines—500 KVA and Larger.](#)

API 547-~~2005~~, General-Purpose Form-Wound Squirrel Cage Induction Motors—250 Horsepower and Larger.

ASTM B117-~~03~~, Standard Practice for Operating Salt Spray (Fog) Apparatus.⁴

³ API publications are available from the Publications Section, American Petroleum Institute, 1200 L Street NW, Washington, DC 20005, USA (<http://www.api.org/>).

⁴ ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

IEC 60034-8, Rotating Electrical Machines—Part 8: Terminal Markings and Direction of Rotation.⁵

IEEE Std 1TM ~~2000 (Reaff 2005)~~, IEEE Recommended Practice—General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.^{6, 7}

IEEE Std 43TM ~~2000~~, IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery.

[IEEE Std 62.2TM, IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus—Electrical Machinery.](#)

[IEEE Std 62.2TM-2004 \(7.2.3\), IEEE Guide for Diagnostic Field Testing of Electric Power Apparatus—Electrical Machinery.](#)

[IEEE Std 95TM-2002, IEEE Recommended Practice for Insulation Testing of AC Electric Machinery \(2300 V and Above\) with High Direct Voltage.](#)

⁵ IEC publications are available from the ~~Sales Department of the~~ International Electrotechnical Commission, Case Postale 131, 3 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

⁶ The IEEE standards or products referred to in this clause are trademarks owned by the Institute of Electrical and Electronics Engineers, Incorporated.

⁷ IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

IEEE Std 112™-2004, IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
IEEE Std 115™-1995, IEEE Guide: Test Procedures for Synchronous Machines.

IEEE Std 432™-1992 (withdrawn), IEEE Guide for Insulation Maintenance for Rotating Electrical Machinery (5 Hp to less than 10 000 Hp).⁸

IEEE Std 510™-1983 (withdrawn), IEEE Recommended Practice for Safety in High-Voltage and High-Power Testing.⁹

IEEE Std 522™-2004 (Reaff 2009), IEEE Guide for Testing Turn-to-Turn Insulation on Form-Wound Stator Coils for Alternating-Current Rotating Electric Machines.

IEEE Std 841™, IEEE Standard for Petroleum and Chemical Industry—Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).

[ISO 1940, Balance Requirements of Rigid Rotors.](#)

NEMA MG 1-~~2006~~, Motors and Generators.¹⁰

⁸ IEEE Std 432-1992 has been withdrawn; however, copies can be obtained from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

⁹ IEEE Std 510-1983 has been withdrawn; however, copies can be obtained from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

¹⁰ NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).

3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards*

[NEMA MG 1-2014 \(Part 7\), Motors and Generators. NEMA MG 1-2014 \(4.15\), Motors and Generators.](#)

Dictionary ~~Glossary of Terms & Definitions~~ [Online](#) should be [consulted](#) for terms not defined in this clause.¹¹

accepted test: A test on a system or model system that simulates the electrical, thermal, mechanical, and environmental stresses occurring in service.

insulation class: Insulation systems are divided into classes according to the thermal endurance of the system for temperature rating purposes. NEMA classes of insulation systems used in motors include Classes A, B, F, and H. These classes have been established in accordance with IEEE Std 1TM.¹² The insulation systems shall be as follows:

¹¹IEEE Standards Dictionary: ~~Glossary of Terms & Definitions~~ [Online subscription](#) is available at:

http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

¹²Information on references can be found in Clause 2.

- a) NEMA Class A: An insulation system (105 °C temperature limit which is typically a 65 °C rise above a 40 °C ambient) that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting Class A temperature specified in the temperature rise standard for the machine under consideration.
- b) NEMA Class B: An insulation system (130 °C temperature limit ~~including or~~ which is typically a 90 °C rise above a 40 °C ambient) that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting Class B temperature specified in the temperature rise standard for the machine under consideration.
- c) NEMA Class F: An insulation system (155 °C temperature limit ~~including~~ which is typically a 115 °C rise above a 40 °C ambient ~~or 115 °C rise~~) that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting Class F temperature specified in the temperature rise standard for the machine under consideration.
- d) NEMA Class H: An insulation system (180 °C temperature limit ~~including~~ which is typically a 140 °C rise above a 40 °C ambient ~~or 140 °C rise~~) that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting Class H temperature specified in the temperature rise standard for the machine under consideration.

insulation system: An assembly of insulating materials in association with the conductors and the supporting structural parts. All the components described as follows that are associated with the stationary winding constitute one insulation system, and all the components that are associated with the rotating winding constitute another insulation system:

- a) Coil insulation with its accessories: All the insulating materials that envelop and separate the current-carrying conductors and their component turns and strands, and form the insulation between them and the machine structure; includes wire coatings, varnish, encapsulants, slot insulation, slot fillers, tapes, phase insulation, [semi-conductive and gradient stator coil coatings](#), pole-body insulation, and retaining ring insulation when present.
- b) Connection and winding support insulation: All the insulation materials that envelop the connections that carry current from coil to coil, and from stationary or rotating coil terminals to the points of external circuit attachment; and the insulation of any metallic supports for the winding.
- c) Associated structural parts (insulation system): Items such as slot wedges, space blocks, and ties that are used to position [or support](#) the coil ~~ends~~ and connections; any non-metallic supports for the winding; and field-coil flanges.

motor: A rotating machine that converts electrical power into mechanical power.

record: Process whereby a physical condition is permanently documented by means of a photograph, sketch, drawing, diagram, writing or printing, rubbing, and similar means. Record also extends to charts, tables, output(s) from instrument(s) or sensor(s) (e.g., magnetic tape), processed electronic signal(s), computerized data files, and the like.

repair: Includes incoming inspection and test, damage appraisal, cleaning, replacement or restoration of damaged part(s) or both, assembly, post-repair inspection and test, and refinishing. Damage resulting from a motor failure varies widely as do the associated repair costs. Evaluation processes that consider various levels of repair, [or the application](#), are better enabled to yield accurate assessments. For example:

- Level 1—Basic reconditioning. Includes replacing of ~~antifriction~~ [rolling element](#) bearings or inspection and verification of hydrodynamic bearings, cleaning all parts, and replacing lubricant. Also adds seals and other accessories as agreed with customer.
- Level 2—Includes Level 1 with the addition of varnish treatment of stator windings, repair of worn bearing fits, and straightening of bent shafts- [\(when specifically approved by purchaser\)](#).
- Level 3—Includes Level 1 and rewinding the stator (replacing windings and insulation).
- Level 4—Includes rewinding of the stator plus major lamination repair or rotor rebar. May include replacement of the stator laminations or restacking of laminations. Shaft replacement would normally fall into this category. In short, Level 4 involves major repairs that are costly enough to justify examining the option of replacement.
- Level 5—Motors that would normally be replaced except for special circumstances faced by the customer (i.e., no spare or unacceptable lead time for a replacement). Level 5 includes misapplied motors, inadequate enclosures, and pre U-frame motors. A motor that should be replaced, if not for the owners' inability to operate without it.

NOTE—There may be cases where multiple levels apply to the same motor.¹³

¹³ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

repair facility: The entity contracted to make repairs, which includes the “on site” repair(s) made by employees of that entity in addition to repair(s) made at a service center operated by or under the supervision of that entity.

total indicated runout (TIR): The difference between highest and lowest reading of a dial gauge touching a shaft (mechanical runout) or rotor, or a properly adjusted non-contacting proximity probe sensing the shaft surface (electrical runout) at a designated location on a shaft as it is slowly rotated through a complete revolution. The readings shall be taken with the shaft in its bearings, on “V blocks,” or in centers, and may be different depending on the method used.

user: The owner of the motor or an authorized agent of the owner.

4. Responsibilities

Items to be considered and documented throughout the various stages of refurbishment and repair vary in number depending on the level of repair to be undertaken. The definition of issues and their resolution ranges from simple to complex, where complicated problems may require several iterative investigations and solutions. This begins at the user’s facility prior to removal of the motor and then continues through pre-repair appraisal, dismantling, component evaluation, refurbishment or repair, and final testing at the repair facility. Some users may continue recording and evaluation during the re-installation and startup process. The items, steps, or processes noted within this document are not listed in any specific order and may be modified, added, or deleted as necessary; performed in a different order; or conducted simultaneously.

Photographs are part of the appraisal process and inspection report and may be necessary for reassembly or failure analysis. Photographs are useful for clarifying conditions that cannot be described adequately; documenting location, orientation, or special markings; or identifying the extent of visible damage. Examples include conduit locations, cable routing, fan orientation, stator coil damage, broken rotor bars, and so on. [Photography is also useful in documenting the arrangement of complex parts, and for providing a record throughout the repair process.](#) The use of digital photography is [highly](#) encouraged.

In the absence of clear photographs, any drawings, sketches, diagrams, or descriptions should allow no uncertainty as to the location of the conditions described. If references are made to “clock position” or to ends of the motor (e.g., “inboard” or “outboard”), some explanatory note or sketch should make clear the location being described. The terms “drive end” and “opposite drive end” are recommended for horizontal shaft motors, and “top” and “bottom” are recommended for vertical shaft units.

4.1 User responsibility

To ensure that the repair operation is of high quality and is cost effective, the user should make advance preparation and prequalification of the repair facility. These steps should be finished prior to motor failure or shipment of the unit. [The user may designate a representative to coordinate communication with the repair facility.](#)

4.1.1 Records

The user should keep a record of the nameplate and other motor information in a file along with any data such as baseline, operational performance, failure history, bearing replacement, and other problems and repairs. When furnished to the repair facility, these records are critical to the diagnosis, evaluation, and repair process. For example, at times, the nameplate will not be legible after several years in service.

4.1.2 Repair facility prequalification

The user should prequalify several local repair facilities according to the type of repairs that may be required. The following are suggested guidelines for particular areas of repair:

- a) *Crane equipment capacity.* The capacity and condition of lifting equipment ~~should~~ must be adequate to handle large motors safely and smoothly. Lifting equipment ~~should~~ must be adequate for the largest motor for which that facility is being prequalified.
- b) *Cleanliness.* Facilities should be clean and orderly, and tools and equipment should be in good repair. Winding areas and bearing installation areas, containers, and equipment used to apply the insulation system should have special emphasis.
- c) *Lighting.* Health and safety recommendations suggest 600 lux (55 foot-candles) minimum, with 750 lux (70 foot-candles) minimum for precision work areas.

- d) *Insulation requirements.* The facility ~~should~~ must have the necessary equipment to install and test adequately the integrity of the insulation system.
- e) *Offsite supply and repair.* Where components, such as coils, shafts, bearings, and brackets, are supplied or repaired at a different location, care shall be taken in handling, packing, and transporting those parts.
- f) *Instrumentation.* The repair facility shall have adequate instrumentation and measurement equipment to perform properly all tests and that equipment ~~should~~ must be calibrated at least annually. Calibration shall be documented and traceable to a recognized national standard. Backup instruments are recommended for data verification.
- g) *Removal of windings.* Facilities for removing windings safely and without damaging motor laminations shall be available.
- h) *Rotor balancing.* Rotor balancing and vibration analysis equipment shall be available for the largest motor and speed for which that facility is being prequalified.
- i) *Quality assurance program.* The repair facility shall have a formal quality control/quality assurance (QC/QA) program in place.
- j) *Machining.* The repair facility shall have sufficient machinery (lathes, mills, etc.) capable of properly handling the size and weight of the various motor components requiring repair or refurbishment. Included are the necessary tools, fixtures, cutting elements, and other appurtenances required for the work and consistent with the tolerances required for a high-quality repair.

- k) *Cleaning.* The repair facility shall have the equipment and training necessary for the various types of mechanical and electrical component cleaning required in the repair process. It is also the responsibility of this facility to ensure that cleaned components are suitable for human handling and do not pose present or future environmental risk.
- l) *Test stand.* The repair facility should be evaluated on the capabilities of its test stand(s) with respect to the sizes and ranges of the motor(s) for repair or refurbishment, such as kW (hp), voltage, starting capability, rpm and speed range, mounting position, motor physical size and weight, oil- or water-cooling capacity, air ventilation capability, load or heat run test capabilities, excitation panels, and adjustable frequency drive systems.
- m) *Standards and references.* The repair facility should possess and have readily available at site the current version of standards and reference documents relating to the materials, components, assemblies, and completed motor with respect to the testing, performance, and evaluation criteria thereof.
- n) *Safety program.* The repair facility shall have a formal safety program, and ensure that workers are properly trained.
- o) *Evaluation form.* A typical repair facility evaluation form is included as Annex B.

4.1.3 Diagnostics in user's plant

While a motor is operating in the user's plant, certain tests and measurements can be performed that will assist with determination of the problem and possible future repair facility work. These include the following:

- a) Measurement of current and voltage on all phases, with attention to unbalances.
- b) Temperatures such as frame, bearing housing, stator, and bearing. Include the method of measurement.
- c) Vibration spectrum.
- d) Other operational behaviors including noise, slip, [and](#) event cyclical occurrence.
- e) Current signature analysis.
- f) Data such as insulation resistance records, partial discharge records, lubricant analysis, maintenance history, or other information that may be available.
- g) Application details such as type of driven equipment, load characteristics, loading and duty cycle, method of coupling, starting requirements, starting method, total number of starts, starting frequency, direction of rotation, installation arrangement, and any unusual conditions or requirements.
- h) Environmental description including ambient temperature range, precipitation, and exposure to contaminants (liquids, solids, or gases). [Where applicable, documentation of auxiliary cooling such as water, supplemental air conditioning, etc.](#)
- i) A typical motor application, environment, and condition form is included in Annex C.

4.1.4 Intended work scope and information

The user shall provide the repair facility with the intended work scope, nameplate information, operational and failure history, previous repair records, and user data sheets when available. The motor repair order may also contain special instructions or deviations from this standard. A typical motor repair order is in Annex D.

4.2 Repair facility responsibility

After preliminary inspection and evaluation of the motor, the repair facility shall provide a response to the user's motor repair order. Unless otherwise specified, repair work shall not proceed until the full scope and definition of the work to be performed is agreed on.

Following initial user approval of the work scope, any additional repairs or modifications shall be approved by the user. The repair facility shall provide the user with a proposal for any additional cost and the revised completion date before extra work is performed. Situations may occur where there are schedule constraints on urgent repairs, and extra work becomes necessary when it is not possible to contact the user. In these cases, with prior user approval to maintain the work schedule, the repair facility may proceed with the extra work and make all efforts to inform the user at the first opportunity.

Disposition of all salvageable and non-salvageable material or equipment shall be determined between the repair facility and user at time of delivery of the motor [to the repairer](#).

A thorough appraisal of the motor's condition, as received, is essential for the following purposes:

- To determine what specific repairs are needed. The motor may have been sent to the repair center with limited external evidence as to the nature and location of trouble. The problem may be correctable in several ways.
- To find unsuspected trouble, perhaps unrelated to the obvious defect.
- To diagnose causes and effects to help prevent recurrence.

A detailed damage appraisal of motor components is divided into two categories: mechanical and electrical.

5. Preliminary assessment

5.1 Initial receipt

Prior to unloading the motor, the shipment shall be inspected with the shipper representative for obvious damage that may have occurred during shipment. The repair facility shall file appropriate damage reports and inform the user. A receiving report shall be filled out and ~~include~~ [disclose information regarding any](#) broken or missing parts and/or any unusual problem([s e.g., liquid inside motor, partial discharge, bearings damaged by shaft currents](#)). Prior to evaluation, and at appropriate times during later work, clean the motor and components to the extent required to perform subsequent work.

Record all nameplate information available. The following data should be obtained:

- a) Type of apparatus, such as: horizontal, vertical, partial motor, engine type, ~~hermetic, cryogenic, submersible~~, etc.
- b) Manufacturer
- c) Style, model, type
- d) Serial number
- e) Rated output, as appropriate
 - 1) Horsepower (hp)
 - 2) Kilovolt ampere (kVA)
 - 3) Kilowatt (kW)
- f) Power factor (for synchronous motors or generators)
- g) Rated speed
 - 1) Revolutions per minute (rpm)

- 2) Number of poles, if available

- h) Input power; include information for primary and any secondary or field windings as necessary
 - 1) Voltage(s)

 - 2) Phase and phase sequence (where applicable)

 - 3) Frequency

 - 4) Amperage(s)

 - 5) Locked rotor amps or code letter

 - 6) Winding connection, starting method

- i) Insulation information
 - 1) Insulation class

 - 2) Temperature rise

- 3) Ambient temperature design base
- j) Bearing information
 - 1) Type
 - 2) Manufacturer, as available
 - 3) Identification or markings as available
 - 4) Type of lubricant used
- k) Service factor and service duty limits, if any
- l) Enclosure type and hazardous (classified) area designation (if any)
- m) Information available from additional nameplates, for example:
 - 1) Space heaters (quantity, voltage, and wattage)
 - 2) Auxiliary devices [photographs](#)
 - i) Temperature detectors

- ii) Vibration detectors
 - iii) Surge capacitors, lightning arresters-
 - iv) Current transformers (CTs)
 - v) Air filters and differential pressure switches
 - vi) [Note missing equipment, couplings, top hood, etc.](#)
- 3) Direction of rotation
 - 4) Motor identification tags
- n) Other information as available from the user
 - 1) Vibration reports, signatures, etc.
 - 2) Motor current signature data

5.2 Incoming tests

To determine whether the motor can be run or whether additional work is justified, an initial evaluation is required. Locate or obtain the motor repair order from the user and review it before proceeding with work on the motor. Perform and record the results of the following inspections, tests, and examinations prior to electrical or mechanical connection, and before any running or attempted operation of the motor:

- a) Frame: readily visible damage
- b) Shaft
 - 1) Unrestricted rotation
 - 2) End play or end float (axial movement of shaft)
 - 3) Readily visible shaft distortion
- c) Bearing(s)
 - 1) Adequate lubrication (grease, oil, and oil mist)
 - 2) Readily visible damage

- d) Check type [and](#) condition of coupling and [keyway](#). Notify end-user promptly if damage exists as the mating half is likely to be in the same condition.
- e) Insulation resistance tests. Recommended minimum insulation resistance values are noted in Table1, adopted from IEEE Std 43™-~~2000~~ [2013](#).

**Table 1—~~Guidelines for de voltages to be applied during~~ [Recommended](#)
[minimum](#) insulation resistance ~~test~~ [at 40° C](#)**

Minimum insulation resistance (IR) (megohms)	Test specimen
$IR_{1min} = kV + 1$	For most windings made before about 1970, all field windings and others not described below
$IR_{1min} = 100$	For most ac windings built after about 1970 (form-wound coils)
$IR_{1min} = 5$	For most motors with random-wound stator coils and form-wound coils rated below 1 kV
where IR_{1min} is the recommended minimum insulation resistance, in megohms corrected to 40 °C (104 °F), of the entire motor winding after 1 min kV is the rated motor terminal to terminal voltage, in rms kV	

Source: [Table 4 of](#) IEEE Std 43-~~2000~~ [2013](#).

Insulation tests shall be performed at the voltages in Table 2.

For incoming motors, preliminary (go/no-go) insulation tests shall be performed on all insulated windings at the voltages in Table 2.

Table 2—Guidelines for dc voltages to be applied for incoming test

Rated motor voltage	Megohmmeter test voltage, dc
up to 2400	500
2401 to 5000	2500
5001 to 15 000	2500 or 5000

- f) Motor leads and connections ~~should~~ shall be ~~checked~~ inspected for cracks, signs of overheating, frayed insulation, and loose or burned terminal lugs.
- g) Continuity of stator windings and field coils, if present.
- h) For motors with brushes, verify presence and contact with the collector ring.
- i) For ac induction motors, a defective rotor bar test. Connect a single-phase, low-voltage power source (lowest possible voltage in the range of 15% to 50% of rated voltage) to two phase leads of the stator. With an analog ammeter or chart recorder, monitor the amperage draw as the shaft is slowly rotated manually through complete revolutions. Maximum acceptable variation is 3% of that current drawn while stationary. Not all rotor faults will be detected by this method. The user is encouraged to provide vibration or current signature analysis while the motor is in service, if rotor problems are suspected.
- j) A surge comparison test, if performed with the motor assembled, is often influenced by the number of rotor bars spanned by the phases under comparison. The surge comparison test, if performed prior to cleaning of the winding, should be done at the motors rated voltage.

- k) [The field poles of synchronous machines shall be tested by performing a voltage drop test, as described in item c\) of 6.3.3.](#)

5.3 Initial run check

If it appears it is possible to run the motor, [and the user requests or approves doing so](#), then perform the following setup and testing procedures:

a) Setup

Prior to an initial run test, the following setup items should be followed:

- 1) Motor should be level and setting on a bedplate per IEEE Std 841™ ~~2009~~, ANSI/API 541-~~2003~~, ANSI/API 547-~~2005~~, or ANSI/API 546-~~1997~~, as appropriate.
- 2) Note required direction of rotation.
- 3) Check and record foot planarity (shim out soft foot conditions).
- 4) Mount half coupling or install a half key in keyway with means to prevent axial movement and secure against centrifugal forces.
- 5) Anchor motor securely to bedplate.

- 6) Fill bearing lubrication reservoir(s) with the type, grade, and quantity of lubricant applicable to the bearing design and motor application. Consideration shall be given to any preexisting lubricant implemented by the user.
- 7) For motors with proximity probes, set gap and provide instrumentation for making measurements using this system.
- 8) Ensure any current transformer (CT) secondary terminals are shorted.

b) Run voltage

~~It is desired to run~~ If possible, the motor shall be run at rated nameplate voltage; ~~or if possible. If~~
~~unavailable, the motor may be run~~ at a reduced voltage, recognizing that reduced-voltage conditions
may not reveal problems that might be apparent at full voltage.

c) Run duration

The motor shall be run during this initial run test until the bearing temperatures are stable or 1 hour maximum. Stop the test during this run time for any unusual conditions such as unusual noise, high vibration, high temperatures, or other abnormalities.

d) Measurements during run tests

Record the following data during the run test:

- 1) Motor terminal voltages
- 2) Motor phase currents
- 3) Current unbalance

Phase currents should be essentially balanced. Current unbalance is calculated by the Equations (1) and (2):

$$C_u = \frac{\text{Max deviation}}{\text{Ave}} \times 100 \quad (1)$$

$$\text{Ave} = \frac{A+B+C}{3} \quad (2)$$

where

C_u is the current unbalance

Max deviation is the maximum amperage derivation from average of the three phases

Ave is the average of the three phases

Example: Phase A = 102 A, Phase B = 107 A, and Phase C = 109 A. The average current is 106 A; the maximum deviation is 4 A. Thus, the Cu is $4 \times 100/106 = 3.78\%$.

The current unbalance percentage is much greater than voltage unbalance percentage.

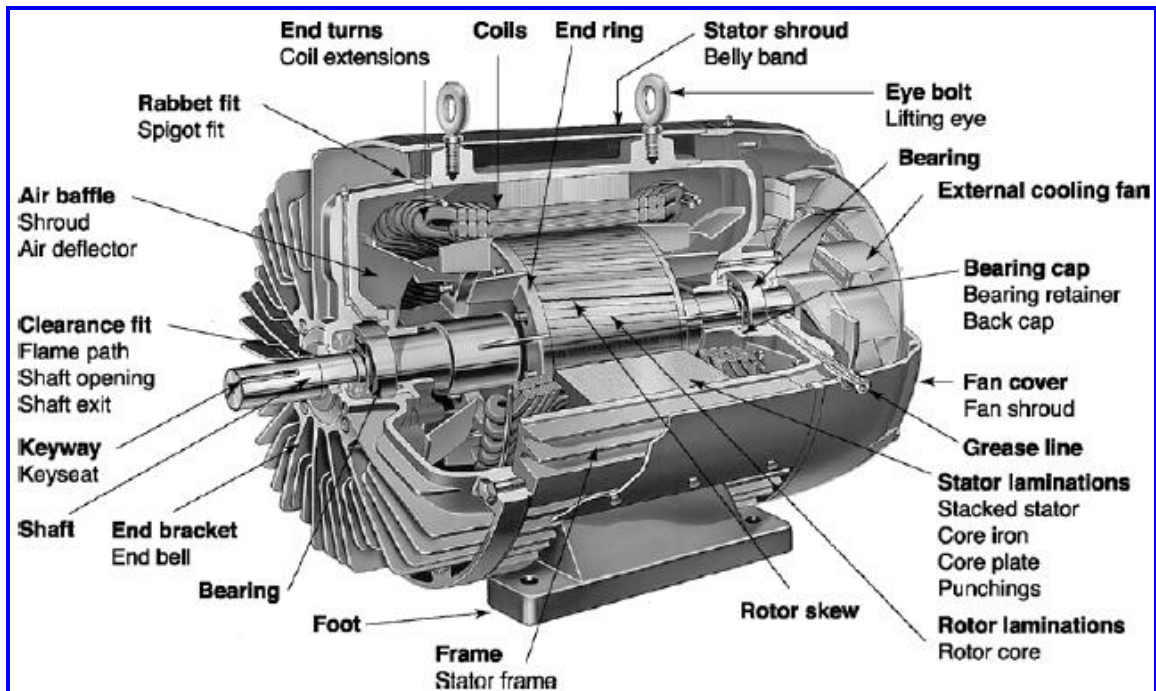
- 4) Shaft speed.
- 5) Vibration on bearing housings; for motors equipped with proximity probes, record vibration values with this method as well. (See 8.7 for balancing and vibration details.)
- 6) All stator and bearing temperatures during the run for motors equipped with resistance temperature detectors (RTDs). On motors without bearing RTDs, use an alternative method to monitor bearing temperatures.
- 7) Field voltage and current on synchronous motors.
- 8) Whether air is entering the filter inlet on motors equipped with a differential pressure sensor across the filter. (Units with multiple filter housings may have a sensor for each location.) Then, temporarily block air flow at the filter inlet to verify sensor operation. For motors having provisions for differential pressure monitoring, record the amount of differential pressure.
- 9) Whether the motor is operating at the marked magnetic center, if so marked.

- 10) Ambient temperature.
- 11) For motors suspected of having rotor thermal instability problems (vibration varies as motor temperature varies), test the motor for response to normal full-load rotor temperatures as well. This can best be done by connecting the motor to a dynamometer to load the motor to full load. Alternative methods as described in 6.2 may also be used but are not always as accurate. See 6.3.3.13 in ANSI/API 541-~~2003~~ [2014](#) and Annex E of ANSI/API 541-~~2003~~ [2014](#), or 4.3.3.11 and Annex G of ANSI/API 546-~~1997~~ [2008](#) for guidance.

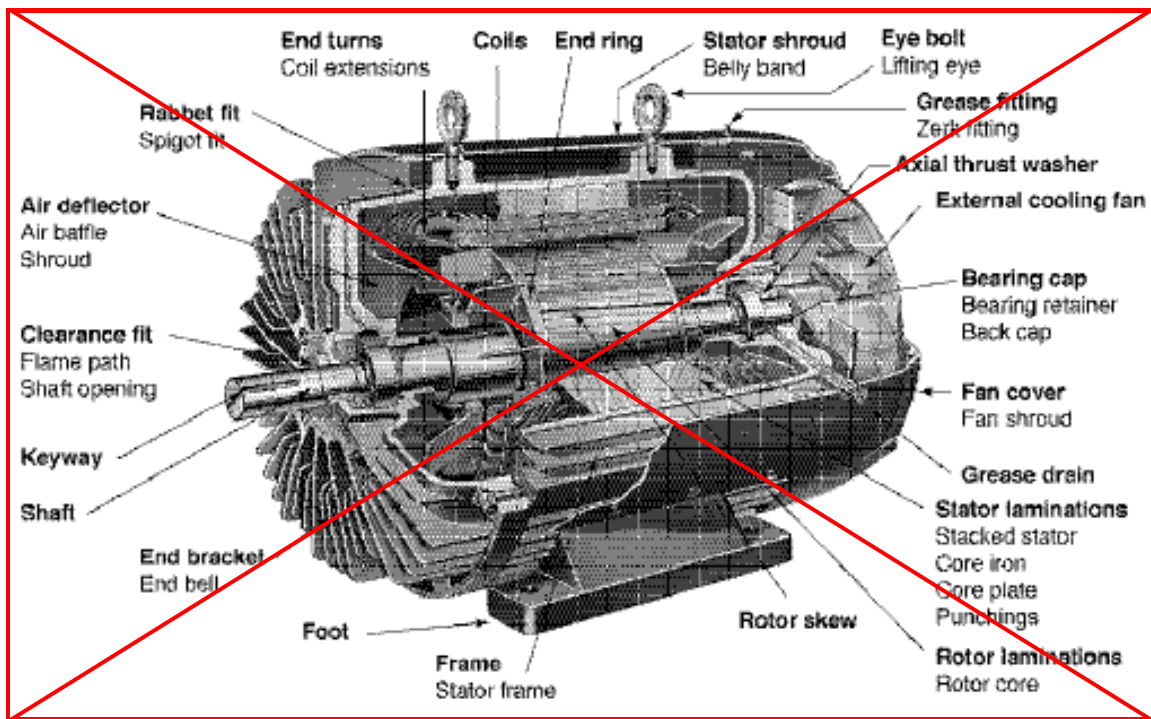
6. Condition and damage appraisal

6.1 Component marking and evaluation

Before any disassembly begins, a general examination of the motor shall be made and general condition observed during disassembly. The typical horizontal motor arrangement and nomenclature is noted in Figure 1. The typical vertical motor arrangement and nomenclature is noted in Figure 2.



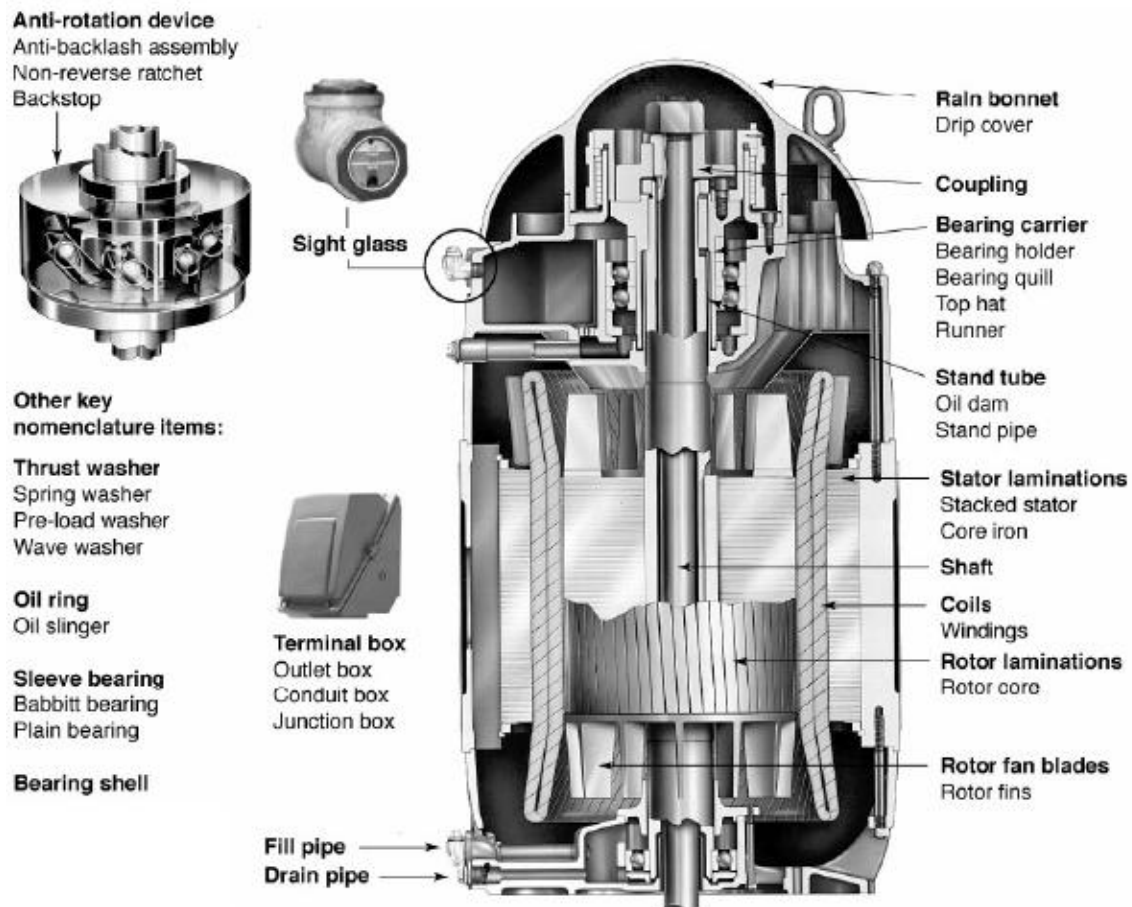
(New)



(Deleted)

NOTE—Figure 1 is reprinted with permission from the Electrical Apparatus Service Association (EASA), *Mechanical Repair Fundamentals of Electric Motors*, 2003.

Figure 1—Typical horizontal motor nomenclature



NOTE—Figure 2 is reprinted with permission from the Electrical Apparatus Service Association (EASA), *Mechanical Repair Fundamentals of Electric Motors*, 2003.

Figure 2—Typical vertical motor nomenclature

During the inspection and dismantling process, the following steps shall be performed:

- a) External parts shall be marked (e.g., brackets, frame, shaft fans, covers, components where matching is critical, etc.).
- b) Frame-mounted auxiliary devices shall be identified and recorded.
- c) Before removing the coupling or other shaft-mounted components, measure and record their position with respect to the end of the shaft (flush, past flush, or ~~from flush~~ [overhung](#)). Indelibly mark the coupling or similar part to identify which side faces out. Critical components may need to be match marked for reassembly. Record the coupling diameter, bore, and keyway.
- d) Examine the coupling, pulley, sheave, or gear. Record any general damage, evidence of wear, condition of bore, keyway, and fit to shaft. Notify the user immediately of problems so the mating half can also be inspected.
- e) Check shaft extension runout compliance with original motor specifications [and customer requirements](#). The runout shall be measured within 25 mm (1 in) of the shaft end. If other information is not available, then select the appropriate speed range and use the total indicated runout (TIR) limits from Table 3. TIR values in excess of these limits, where the motor is performing satisfactorily, should be reviewed with the appropriate parties (e.g., user, manufacturer, etc.) for appropriate disposition.

Table 3—RPM versus allowable total indicated runout

Full load (rpm)	<950	950 to 1450	1451 to 2000	>2000
TIR	0.076 mm (0.0030 in)	0.051 mm (0.0020 in)	0.038 mm (0.0015 in)	0.0254 mm (0.0010 in)

- f) Check the level and condition of the lubricant, including the color and smell, and note the presence of foreign liquids or metal particles. If abnormalities are observed, a sample of the lubricant shall be taken.
- g) If the motor design permits, check and record the main and exciter air gap measurements, where applicable, at four points on each end of the motor. When only three readings are possible, assume that the sum of the 180° opposite readings is equal for both directions. Take measurements at 90° intervals of shaft rotation. No reading shall have a deviation in excess of 10% of the average of all four readings. Where motor design does not permit pre-disassembly measurement of the air gap and symptoms of dissymmetry or anomalies exist (such as vibration, electrical noise, etc.), various methods may be required to determine these values.
- h) Mounting feet flatness. All fully assembled motors with mounting feet shall have a mounting surface maximum coplanar tolerance of 0.127 mm (0.005 in) when measured in accordance with Section 4.15 of NEMA MG 1-~~2006~~ 2014. [If the feet are not parallel, that may indicate distortion of the frame. Causes include improper manufacture or handling, burnout while not well supported, etc.](#)

- i) All wiring, including main power leads, enclosure, and bearing grounding connections, enclosure bonding straps, and accessory devices (such as winding and bearing temperature detectors, vibration sensors, filter monitors, space heaters, surge capacitors, lightning arresters, instrumentation transformers, etc.) shall be properly marked and recorded before disconnection so that these wires and devices are returned to the same location and orientation during reassembly. Care shall be taken to duplicate the received wire or lead markings. Non-standard markings shall be cross referenced to NEMA or IEC standard terminal markings.
- j) Location and orientation of terminal boxes and box seals, conduit and conduit seals, conductor supports, and accessory mounting [e.g., surge capacitor(s), lightning arrester(s), CTs, etc.] shall be recorded.
- k) Condition of all power leads, auxiliary device wiring, lugs, cable terminations, insulators, and terminal blocks shall be recorded.
- l) Proximity probes, where present, shall be examined for wear or damage to probes, wiring, and probe tracks. [Where requested, electrical runout should also be verified. Probe track areas should be protected \(wrapped or covered\) during the duration of the time in the repair center.](#)
- m) Bearing oilers [or sight glasses](#), where present, shall be inspected for missing parts, stained globes (reservoirs), and so on. Note the condition on the inspection and repair report. Replace where necessary.

- n) Bearing temperature detectors (RTDs, thermocouples, etc.), where present, shall be tested for rating and continuity. Validation of the output versus temperature characteristics may be required to confirm specific sensor type or behavior. The sensor(s) shall be replaced where defective. Where insulated bearings are required, or where bearing insulation is present, verify that the sensor is electrically insulated from the bearing shell. For motors operating from sinusoidal power, the minimum bearing resistance shall be 1 MΩ at 100 V, or as directed by the end user. For machines operating from an adjustable-speed drive (ASD), impedance measurement is recommended. The capacitive coupling effect between stator and rotor, for a motor operating from an ASD, makes it useful to know the capacitance as well as resistance.
- o) Air filters, where present, shall be inspected. Washable filters in good condition shall be retained for reuse. Damaged or non-reusable filters are to be replaced with like kind. Where it appears that the filter or filter media has not met the necessary performance requirements, the user shall be consulted regarding replacement with an alternative type of media or filtering efficiency.
- p) Where sound-attenuating material must be reattached, evaluation of the material shall be made to determine whether its performance and mechanical stability is acceptable. Where the original material is unsuitable and replacement is required, the new material shall be attached in a manner recommended by the manufacturer of the soundproofing. Should adhesive means be not acceptable to the user, alternative mechanical means may be considered.

6.2 Detailed mechanical evaluation

As disassembly proceeds, parts shall be marked or recorded by other methods as soon as practical. Detailed and specific condition shall be observed during disassembly. [Photographs are particularly important to this stage.](#) Where necessary, individual component characteristics may be determined and recorded immediately after removal, or measured and recorded after disassembly is complete. Some detailed inspection points ~~further the examination of~~ [among](#) those listed below [require examination using a digital surface gage \(e.g., surface finish of shaft journals, bearing housings, etc.\) in order to provide an adequate summary of their condition.](#) The following list of items shall be included where required by the user, or considered where appropriate:

a) Frame

Where not previously marked, brackets, bearing caps, and bearings shall be identified as sets. Bearing orientation shall be recorded.

Inspect housing and frame for defects, including:

- 1) Weld condition
- 2) Structural integrity
- 3) Cracks