



IEEE Recommended Practice for the Repair and Maintenance of Direct Current Electric Machines

IEEE Industry Applications Society

Developed by the
Petroleum and Chemical Industry Committee

IEEE Std 2455™-2023

STANDARDS

IEEE Recommended Practice for the Repair and Maintenance of Direct Current Electric Machines

Developed by the

Petroleum and Chemical Industry Committee
of the
IEEE Industry Applications Society

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IEEE SA Standards Board

Abstract: Best practice methods for the inspection, testing, mechanical repair, rewinding, assembly and acceptance testing, as well as recommended and maintenance practices for direct current electric motors and generators, are covered in this recommended practice.

Keywords: armature, dc generator, dc machine, dc motor, direct current, fields, IEEE 2455™, interpole, refurbish, repair, repair facility, rewind, service facility

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Introduction

This introduction is not part of IEEE Std 2455-2023, IEEE Recommended Practice for the Repair and Maintenance of Direct Current Electric Machines.
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This Recommended Practice is intended to be a basic or primary document that can be utilized and referenced by users of dc 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.

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[Table 1](#), [Table 2](#), and [Table 3](#) are derived from IEEE Std 43™-2013 [B6].⁶

⁶The numbers in brackets correspond to those of the bibliography in [Annex A](#).

Contents

1. Overview	11
1.1 Scope	11
1.2 Purpose	11
1.3 Word usage	12
2. Normative references	12
3. Definitions, acronyms, and abbreviations	13
3.1 Definitions	13
3.2 Acronyms and abbreviations	14
4. Responsibilities	15
4.1 User responsibility	15
4.2 Repair facility responsibility	17
5. Preliminary assessment	18
5.1 Initial receipt	18
5.2 Incoming tests	19
5.3 Initial run check	21
6. Condition and damage appraisal	22
6.1 Component marking and evaluation	22
6.2 Detailed mechanical evaluation	25
6.3 Detailed electrical evaluation	32
6.4 Brush rigging evaluation	34
7. Cleaning and reconditioning	36
8. Facility repair or refurbishment period	36
8.1 Armatures	36
8.2 Field frames, brush rigging, and associated parts	37
8.3 Stripping and recording of winding data	38
8.4 Armature and frame lamination evaluation	39
8.5 Field winding types	40
8.6 Replacement of coils	42
8.7 Bearing replacement and restoration of rotational fits and seals	43
8.8 Balancing	44
8.9 Electrical connections	45
8.10 Connection methods	45
8.11 Other mechanical fits	49
8.12 Painting	49
8.13 Permanent magnet fields	49
8.14 Final test	50
8.15 No-load vibration testing	51
9. Preparation for shipping	52
10. Field service and repairs	52
11. Post repair	52
11.1 Repair facility	52
11.2 Receiving at site	52
11.3 User handling	53
11.4 Storage	53

Annex A (informative) Bibliography.....	56
Annex B (informative) Typical repair facility Evaluation and Repair Form ²¹	57
Annex C (informative) Commutator and commutation.....	61
Annex D (informative) Sleeve bearing clearance	65
Annex E (informative) Ventilation and cooling	68
Annex F (informative) Post-assembly electrical adjustments	73
Annex G (informative) Bearing currents in dc machines.....	74

IEEE Recommended Practice for the Repair and Maintenance of Direct Current Electric Machines

1. Overview

1.1 Scope

This document covers general recommendations for the repair of dc 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 it is equal to, the terms dc motor, dc generator, and dc machine.

This standard covers reconditioning, repair, and rewind of horizontal and vertical wound-field direct current motors and generators. It applies to all ratings above 0.75 kW (1 hp).

This standard applies only to the repair of machines, 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 should verify if the repair facility should be certified by such an agency. Also excluded are permanent magnet (PM) machines.

1.2 Purpose

This standard is intended to be used and referenced by users of motors that need repair as well as by users and operators of establishments that offer motor repair services. It has been developed primarily for the needs of the petroleum, chemical, paper and other process industries but can be adapted to other applications or industries such as traction motors, rolling mill motors, mine hoists, motor-generator sets, excavators, ship propulsion and oil field.

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.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{7,8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

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.

IEC 60034-8, Rotating Electrical Machines—Part 8: Terminal Markings and Direction of Rotation.⁹

IEEE Std 1™, IEEE Recommended Practice—General Principles for Temperature Limits in the Rating of Electric Equipment and for the Evaluation of Electrical Insulation.^{10,11}

IEEE Std 432™, IEEE Guide for Insulation Maintenance for Rotating Electric Machinery (5 hp to Less Than 10 000 hp).

IEEE Std 522™, IEEE Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines.

IEEE Std 792™, IEEE Recommended Practice for the Evaluation of the Impulse Voltage Capability of Insulation Systems for AC Electric Machinery Employing Form-Wound Stator Coils.

ISO 21940-11, Mechanical Vibration—Rotor Balancing—Part 11: Procedures and tolerances for rotors with rigid behavior.

NEMA MG 1, Motors and Generators.¹²

⁷The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁸The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

⁹IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

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3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹³

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 1™.¹⁴ The insulation systems should be as follows:

- 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 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 which is typically a 115 °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 F temperature specified in the temperature rise standard for the machine under consideration.
- d) *NEMA Class H:* An insulation system (180 °C temperature limit which is typically a 140 °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 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, 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) *Commutator:* The insulation (usually mica) insulating the supporting hub from the conducting bars, as well as the insulation between commutator bars.
- d) *Associated structural parts (insulation system):* Items such as slot wedges, space blocks, and ties that are used to position or support the coil and connections; any nonmetallic supports for the winding; and field-coil flanges.

¹³IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

¹⁴Information on references can be found in [Clause 2](#).

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

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 rolling element bearings or inspection and verification of hydrodynamic bearings, cleaning all parts, and replacing lubricant. Includes turn and undercut of the commutator. Also adds seals and other accessories as agreed with customer.
- *Level 2:* Includes Level 1 with the addition of varnish treatment of armature or field windings, repair of worn bearing fits, and straightening of bent shafts (when specifically approved by purchaser).
- *Level 3:* Includes Level 1 and rewinding the armature or field frame components (replacing windings and insulation).
- *Level 4:* Includes rewinding of the armature, fields or interpoles, plus major lamination repair. May include replacement of the armature laminations or restacking of laminations. Shaft replacement would normally fall into this category.
- *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-NEMA-frame motors. A motor that should be replaced, if not for the users' inability to operate without it.

NOTE—There may be cases where multiple levels apply to the same motor.¹⁵

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 armature, 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 should 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.

3.2 Acronyms and abbreviations

DLRO	digital low-resistance ohmmeter
hipot	high-potential
IR	insulation resistance

¹⁵Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

OEM	original equipment manufacturer
PM	permanent magnet
RTD	resistance temperature detector
TIG	tungsten inert gas
TIR	total indicated runout

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 connections and routing, fan orientation, coil damage, commutator damage, 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 machine (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 machines, 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 machine failure or shipment of the unit. The user may designate a representative to coordinate communication with the repair facility. Communication of known or suspected problems, reason for removal from service, etc. are helpful.

4.1.1 Records

The user should keep a record of the nameplate and other machine information (i.e., original machine manufacturer info—outline drawing, performance data, and test report among others) 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 must be adequate to handle large machines safely and smoothly. Lifting equipment must be adequate for the largest machine 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 lx (55 fc) minimum, with 750 lx (70 fc) for precision work areas.
- d) *Insulation requirements.* The facility 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 should be taken in handling, packing, and transporting those parts.
- f) *Instrumentation.* The repair facility should have adequate instrumentation and measurement equipment to perform properly all tests and that equipment must be calibrated at least annually. Calibration should 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 machine laminations or the commutator should be available.
- h) *Armature balancing.* Armature balancing and vibration analysis equipment should be available for the largest machine and speed for which that facility is being prequalified.
- i) *Quality assurance program.* The repair facility should have a formal quality control/quality assurance (QC/QA) program in place.
- j) *Machining.* The repair facility should have sufficient machinery (lathes, mills, etc.) capable of properly handling the size and weight of the various machine 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. Where a machining subcontractor is used, the repair shop should oversee the work, and the relevant clauses of this standard will apply.
- k) *Cleaning.* The repair facility should 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 machine(s) for repair or refurbishment, such as kilowatt (horsepower), voltage, starting capability, r/min and speed range, mounting position, machine physical size and weight, oil or water cooling capacity, air ventilation capability, load or heat run test capabilities, current-regulated excitation panels, and adjustable frequency drive systems. Load testing of dc machines should not be undertaken without a suitable blower similar to that used in situ to prevent overheating of the windings.
- 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 machine with respect to the testing, performance, and evaluation criteria thereof.

- n) *Safety program.* The repair facility should have a formal safety program and ensure that workers are properly trained.
- o) *Evaluation form.* A typical repair facility Evaluation and Repair Form is included as [Annex B](#).

4.1.3 Diagnostics in user's plant

While a machine 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 armature and fields.
- b) Temperatures such as frame, bearing housing, stator, and bearing. Include the method of measurement.
- c) Vibration spectrum.
- d) Commutator profile measurement, contact or non-contact.
- e) Other operational behaviors including sparking of the brushes, noise, load and speed, direction of rotation, event cyclical occurrence.
- f) Data such as insulation resistance (IR) records, lubricant analysis, maintenance history, differential rates of brush wear, frequency of brush replacement, 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.

4.1.4 Intended work scope and information

The user should 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 machine repair order may also contain special instructions or deviations from this standard. A typical machine Evaluation and Repair Form is in [Annex B](#).

4.2 Repair facility responsibility

After preliminary inspection and evaluation of the machine, the repair facility should provide a response to the user's machine repair order. Unless otherwise specified, repair work should 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 should be approved by the user. The repair facility should 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 should be determined between the repair facility and user at time of delivery of the machine to the repairer.

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

- To determine what specific repairs are needed. The machine 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 machine components is divided into two categories: mechanical and electrical.

5. Preliminary assessment

5.1 Initial receipt

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

NOTE—Some older machines used asbestos insulation, requiring special handling precautions and abatement.

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

- a) Type of apparatus, such as: horizontal, vertical, partial machine, engine type, etc.
- b) Manufacturer
- c) Style, model, type
- d) Serial number
- e) Rated output, as appropriate
 - 1) Horsepower (hp) and/or kilowatt (kW)
 - 2) Rated armature and field voltages and currents, and field resistance when available
- f) Rated speed
 - 1) Revolutions per minute (include base speed and field weakened speed)
 - 2) Number of field poles and interpoles
- g) Input power; include information for primary and any secondary or field windings as necessary
 - 1) Voltage(s)
 - 2) Amperage(s)
 - 3) Winding connection type: shunt, series, PM, or compound fields
- h) Insulation information
 - 1) Insulation class
 - 2) Temperature rise
 - 3) Ambient temperature design base

- i) Bearing information
 - 1) Type
 - 2) Manufacturer, as available
 - 3) Identification or markings as available
 - 4) Enclosure (open, shield or sealed)
 - 5) Type of lubricant used
- j) Service duty limits, if any
- k) Enclosure type and hazardous (classified) area designation (if any)
- l) 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) Auxiliary blower(s)
 - iv) Air filters and differential pressure switches
 - v) Record missing equipment: couplings, blower, tachometer, top hood, covers, etc.
 - 3) Direction of rotation
 - 4) Machine identification tags
- m) Other information as available from the user
 - 1) Vibration reports, signatures, etc.

5.2 Incoming tests

To determine whether the machine can be run or whether additional work is justified, an initial evaluation is required. Locate or obtain the machine repair order from the user and review it before proceeding with work on the machine. 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 machine. Some of the following tests are more practical after disassembly:

- 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. Document coupling fit runoff.

- e) Insulation resistance tests. Recommended minimum IR values are noted in [Table 1](#).

Table 1—Recommended minimum IR

Minimum IR (MΩ)	Test specimen
$IR_{1min} = kV + 1$	For all dc field windings
$IR_{1min} = 5$	For dc armatures

where

IR_{1min} is the recommended minimum IR, in megohms corrected to 40 °C (104 °F), of the entire motor winding after 1 min
 kV is the rated direct voltage for dc machines

Source: Table 4 of IEEE Std 43-2013 [B6]

Insulation tests should be performed at the voltages in [Table 2](#).

For incoming machines, preliminary (go/no-go) insulation tests should be performed on all insulated windings (armature or field) at the voltages in [Table 2](#).

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

Rated component winding voltage (V dc)	Megohmmeter test voltage (V dc)
< 1000	500
1000–2500	1000

Source: Table 1 of IEEE Std 43-2013 [B6]

- f) Machine leads and connections should be inspected for cracks, signs of overheating, frayed insulation, and loose or burned terminal lugs.
- g) Continuity of armature windings, interpoles, field coils and compensating windings, if present.
- h) Winding resistance tests. Measure and record the interpole and field windings resistances together with the ambient temperature. These resistance values should be converted to 25 °C.
- i) For machines with brushes, verify presence (full or partial complement of brushes?) and contact with the commutator. Brush positioning, axial and circumferential arrangement.
- j) Commutator surface and pattern. The commutator film is a good indicator of machine performance. See [Annex C](#) for examples and explanations of slot bar marking, etc.
- k) Check and record the main pole and interpole airgap.
- l) The distance between commutator and brush holders should be recorded.
- m) Quantity and part number of carbon brushes should be recorded. Check for mixed grades and manufacturers. Note whether or not all brushes are evenly worn.
- n) If possible, the following tests can be performed before disassembly. If not practical to do so, they should otherwise be performed after disassembly, as follows:
 - 1) An armature bar to bar test (surge comparison or high frequency), if performed prior to cleaning of the winding, should be done at the machines rated voltage.
 - 2) The field poles should be tested by performing a voltage drop test, as described in [6.3.2](#).
 - 3) Commutator runout and diameter should be checked.

5.3 Initial run check

If it appears it is possible to run the machine, 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) Machine should be level and setting on a bedplate.
- 2) Record 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 and secure against centrifugal forces.
- 5) Anchor machine securely to bedplate.
- 6) Fill bearing lubrication reservoir(s) with the type, grade, and quantity of lubricant applicable to the bearing design and machine application. Consideration should be given to any preexisting lubricant implemented by the user.
- 7) For machines with proximity probes, set gap and provide instrumentation for making measurements using this system.
- 8) For loaded testing, separate ventilation is required. Estimate 170 m³/h (100 CFM) per kW loss.

b) Run voltage

If possible, the machine should be run at rated nameplate field current and armature voltage.

c) Run duration

The machine may be run during this initial run test until the bearing temperatures are stable or 1 h maximum. Note that, without the auxiliary blower, the field temperature should be monitored. 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:

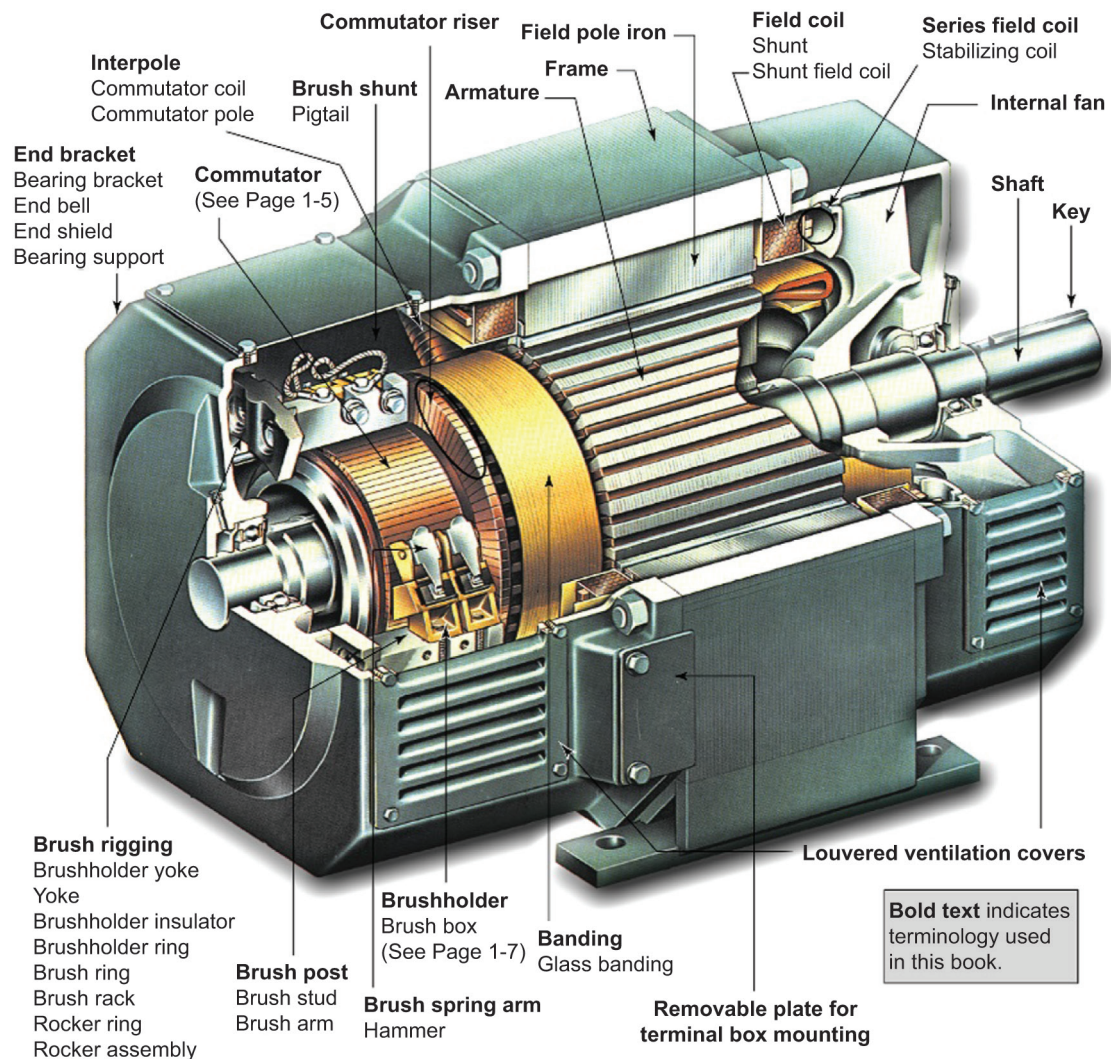
- 1) Machine terminal voltage for armature and fields.
- 2) Machine armature and field currents.
- 3) Shaft speed.
- 4) Vibration on bearing housings; for machines equipped with proximity probes, record vibration values with this method as well. (See 8.8 and 8.15 for balancing and vibration details.)
- 5) All bearing temperatures during the run for machines equipped with resistance temperature detectors (RTDs). On machines without bearing RTDs, use an alternative method to monitor bearing temperatures.
- 6) Whether machine fitted with sleeve bearings is operating at the marked magnetic center, if so marked.
- 7) Ambient temperature.

6. Condition and damage appraisal

For machines suspected of having thermal instability problems (vibration varies as machine temperature varies), test the machine for response to normal full load armature temperatures as well. This can best be done by connecting the machine to a dynamometer to load the machine to full load. An appropriately sized auxiliary blower must be used when load testing a dc machine not fitted with a fan. Condition and damage appraisal.

6.1 Component marking and evaluation

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



Courtesy of *Fundamentals of DC Operation and Repair Tips*, EASA, Inc., 2003–2005, EASA, Inc.

Figure 1—Typical horizontal dc machine nomenclature