DC MOTORS/GENERATORS REPAIR SPECIFICATION

DC MOTOR/GENERATOR REPAIR SPECIFICATION

TABLE OF CONTENTS

DATED: 6/1/99 Revision 05/12/06

References

1. IEEE Std 43-2000 — 345 East 47th St, New York, NY 10017
2. IEEE Std 1068-1996 — 345 East 47th St, New York, NY 10017
3. NEMA MG 1-2003 Rev.1-2004 — 2101 L St NW Suite 300, Washington, DC 20037
4. ISO 8821-1989(E) — 1 rue de Varembe, 1211 Geneva 20, Switzerland
5. ISO 18436-2 — 1 rue de Varembe, 1211 Geneva 20, Switzerland
6. ISO 9921 — 1 rue de Varembe, 1211 Geneva 20, Switzerland
7. ISO 1940/41 — 1 rue de Varembe, 1211 Geneva 20, Switzerland

NWIBRT DC MOTOR / GENERATORS REPAIR SPECIFICATION

1.0 – Overview

1.1 – Mission

This recommended practice covers general recommendations for the repair of DC electric motors and includes recommendations for both the User and the Repair Facility. It is not intended to supplant specific instructions contained in the manufacturer's instruction book or in any contractual agreement between a manufacturer and a purchaser of a given machine.

These recommendations apply to DC motors and generators, having a voltage rating of 750 VDC or less. These recommendations apply only to the rewind and repair of DC motors and generators and are not intended to cover major modifications.

Excluded from the scope of this recommended practice are the following:

- Specific requirements, certification, and inspection required for explosion-proof and dust-ignition-proof machines.
- Any specific or additional requirements for hermetic motors, hydrogen-cooled machines, submersible motors, or Class IE nuclear service motors.

The use of this recommended practice by Users and Repair Facilities is expected to result in higher quality, more cost-effective, and timely repairs. It also provides a means of evaluating repairs and facilities.

1.2 – Purpose

This recommended practice is intended to be a basic or primary document that can be utilized and referenced by owners 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 NWIBRT, but can be adapted to other applications.

2.0 – Definitions

2.1 – Major Modification: Includes conversion from one type of machine to another type of machine, conversion from one type of enclosure to another type of enclosure, or conversion from one rating to another rating.

2.2 – Motor: A rotating machine that converts electrical energy into mechanical energy or mechanical energy into electrical energy. As used in this recommended practice, the term can also be used to mean a generator. For this specification the term motor can also refer to a generator.

2.3 – Repair: Includes incoming inspection and test, damage appraisal, cleaning, replacement and/or repair of damaged part(s), assembly, post repair inspection and test, and refinishing.

2.4 – Repair Facility: The entity contracted to make repairs; includes the “on site” repair(s) made by employees of that entity in addition to repair(s) made at a shop operated by or under the supervision of that entity.

2.5 – User: The owner of the motor or an authorized agent of the owner.

3.0 – Pre-Repair Activity and Responsibility

Several items should be considered and documented prior to repairs. Indeed, some pre-qualification activities should be finished prior to failure or shipment to a repair facility. Some of these activities are the responsibility of the User, while others are assigned to the Repair Facility.

4.0 – User Responsibility

In order for the repair operation to be high quality and cost-effective, the User should make advance preparation to schedule and make the motors available for pick up. Special rigging (lift truck or crane) will be provided at the User's site to transport and set the equipment to be repaired on (pickup), and off (delivery), the Repair Facility's transport vehicle.

4.1 – Records

The User should furnish sufficient manufacture and previous repair information to aid the Repair Facility to make the best failure investigation and repair plan. For example, at times the nameplate will not be readily readable after several years in service, and pertinent data must be obtained largely by measurements. It would be ideal if the User would keep a record of the nameplate and other motor information, connection, and outline drawings**,** in a file along with any data such as failure history, bearing replacement, and other problems and repairs. This record would then be furnished to the Repair Facility if available. Records shall be archived by Repair Facility and the User for a minimum of 10 years.

5.0 – Repair Facility Responsibility:

As a minimum, the Repair Facility shall comply:

ISO-9000 Quality Certification required
Only Class 155 or 180 or better materials, as a total insulation system shall be used.
All materials used for repair shall be new.
Any reused parts shall be approved by the User and completely reconditioned.
Records shall be archived by the Repair Facility for a minimum of 10 years.

6.0 – Incoming Inspection

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. What seems wrong may be correctable in several ways.)
- To find unsuspected trouble, perhaps unrelated to the obvious defect.
- To diagnose cause and effect to help prevent a recurrence.

This appraisal should include a complete review of the following conditions of each part of the motor:

- General cleanliness
- Cracked or broken welds or castings
- Missing hardware
- Wear or rub marks, including fretting

- Discoloration, charring, or other evidence of overheating
- Looseness at mating fits
- Corrosion, moisture, or oil inside the machine

Photographs of any abnormal conditions found are strongly recommended as part of the appraisal process and inspection report. In the absence of clear photographs, all drawings, diagrams, or descriptions shall 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.

Prior to unloading the motor, it should be inspected for obvious damage that may have occurred during shipment.

A. A receiving report should be filled out and include broken or missing parts and/or any unusual problem(s), include photos.

B. For conditions that cannot be adequately described, pictures should be taken for clarity.

C. Record all motor nameplate information available on Appendix B and C as applicable.

6.1 – Incoming Tests

Prior to the incoming run test, perform the following and record information properly*:*

A. General inspection – See paragraph 6.0 and 7.1. Motor must be mechanically inspected to determine if shaft turns freely.

B. Verify that bearings are lubricated.

C. Insulation resistance tests should be performed – Megeohmmeter, polarization index, bar to bar, armature, fields, space heaters, to ground, armature to fields and thermostats; dielectric-non-destructive DC Hipot on armature and fields. (See Section 8.1, I through L for minimum insulation resistance values, temperature compensation requirements, and test voltages.) See Appendixes B and C for a motor data insulation resistance record form.

D. Other tests required before energizing the motor are as follows:

1. Resistance measurements cold of all windings – armature, commutating, compensating, fields
2. Surge comparison testing – pre-detection of coil shorted turns, opens, grounds
3. AC Pole Drop test – pre-detection of coil shorted turns, opens (if #2 is not performed)
4. Air gap measurements – main and commutating poles
5. Armature end play

E. The intent of the "As Received": no load, run test is to get the motor operating safely up to top speed for electrical characteristics, bearing temperature, and vibration checks, prior to disassembly. If the "as found" motor conditions permit, the motor shall be run to 100% speed for these tests. (See Run Test, paragraph 13.0 and 13.3). Complete the data sheets in Appendixes A, C and D.

7.0 – Disassembly Procedures and Instructions

A. Before any disassembly is begun, parts should be marked (i.e., brackets, frame, covers, and brush holders).

B. Brackets and bearings should be identified as pairs.

C. Check and record armature air gap (Appendix B).

D. Frame-mounted devices should be identified and recorded.

E. Wiring should be recorded, sketched, and marked before disconnecting (for external connections).

F. 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). Critical components may need to be match marked for reassembly (Appendix C).

G. Visually check fan blades for damage and cracks. When necessary use a penetrating dye system. Any damaged fan should be replaced.

H. As parts are removed, record all noted damage or special markings.

I. Check shaft extension runout compliance with original motor specifications. If this information is not available, the maximum acceptable and/or permissible shaft run out, when measure a the end of the shaft shall be:

   1. 0.001 inch total indicator reading taken within 0.25" from the end of the shaft.

J. Visually check for evidence of rubbing at outside diameters (fan, shrouds, end rings, armature laminations, etc.).

K. If possible, check for tightness of the armature core on its shaft. Visually inspect for signs of axial and radial movement.

L. Visually check rotating components for excessive heating and other abnormalities.

7.1 – Motor Inspection

General inspection – connection, defects, missing parts, bus and bar joints, vee rings, windings, keyways, threaded fits, all pole pieces, etc.

A. Measure and record dimensions of the following (Appendix C):

   1. Shaft extension
   2. Journal and bearing fits
   3. Shaft extension runout
   4. Shaft seal fits
   5. Commutator diameter, concentricity, appearance of the commutator film
   6. Brush location, size, type, and quantity
   7. Air gap measurements – main, and commutating poles (Appendix B)
   8. Armature end play (Appendix B)

B. Visually inspect the condition of non-rotating components (brackets, baffles, shrouds, brush holders, brushes, gasket, spacers, shims, threaded fits, machine fits, feet, etc.).

C. Measure and record bracket fits for housings, cartridges, and bearings (Appendix C).

D. Visually inspect the condition of ball or roller bearing housing or cartridges (wear, grooving, seal fits, fretting, grease fitting, insulation, oil gages, etc.).

E. Visually inspect the condition of sleeve bearings while still in brackets (wear, oil grooves, oil rings, seals, insulation, seal fit, bracket ware, dowels, parts, etc.).

F. Visually inspect all armature core, commutating, and field pole laminations, leads, mounting blocks, welds, machined fits, etc.

G. Visually inspect all space heaters, blower assemblies, over-speed devices, thermostats, etc.

H. When inspecting the armature and the commutator, check for damaged, missing, or improperly seated brushes, commutator bars that are not securely held to the vee ring, etc. Parts should be inspected for signs of arcing and cracks. All cracks and evidence of arcing should be recorded and, if possible, pictures should be taken showing the location of damaged bars. A drawing should be made showing the defective bar location, and all connecting parts between poles and end rings should be identified and recorded on the drawing. Brush data and spring tension shall be recorded on Appendix G for all brushes and springs.

I. Damage appraisal of motor components is divided into two categories, electrical and mechanical.

J. A strip report shall be sent to User for approval prior to starting repairs using Appendix D.

8.0 – Repair Procedures

8.1 – Electrical

On main field and compensating windings and armature observe the following:

A. Slot wedges that are loose, damaged, or have shifted in position.

B. Ties, lashings, or blocking that are loose or broken.

C. Dirt, oil, or moisture deposited on coil surfaces.

D. Coil damage. Besides obvious burning, tracking, or charring, look for loose or cracked tape, coils that have moved within the slot, deposits of dirt or chemicals, and insulation pitted or worn away by airborne abrasive particles. If severe arcing or burning has taken place, inspect the entire unit interior carefully for globules or fragments or molten copper that may have been projected from the failed winding.

E. On lead cables, straps, and bus work, look for cracked, overheated, or frayed insulation; and loose or burned terminal lugs.

F. When a winding shows clear evidence of destructive arcing or overheating, observe and record carefully the location and nature of the damage. If possible, pictures should be taken showing the connecting parts between poles, and should be identified and recorded on the drawing. If all coils appear equally overheated, ventilation failure, over current, stalling, or prolonged overload are likely causes. If only certain coils adjacent to feeder leads have been damaged, especially with relatively little heating, the likely cause is a transient surge voltage on the feeder circuit.

G. Be alert also for evidence of insulation damage caused by flying objects such as broken fan blades within the motor. The impact will typically gouge down to bare copper without any burning unless adjacent turns become short-circuited and failure progresses.

H. Pay close attention, whether or not winding damage is apparent, to all stator ventilating passages. These can be blocked by varnish or contaminants even when a winding looks fairly clean on the surface.

I. If winding damage is apparent, test the insulation resistance for windings using a megohmmeter in accordance with Std. 43-2000. Record the value of insulation resistance (IR) between the winding of the armature, shunt field, space heaters, to ground, armature to fields and thermostats, polarization index, bar to bar. Test voltage, applied for 1 minute, should be as follows:

Rated motor voltage	Megohmmeter test voltage, DC
230/460	500
700/750	1000

J. If the measured insulation resistance corrected to a reference of 40°C is not at least equal to 1 MΩ per 1000 V of motor nameplate rating plus 1 MΩ, the winding should be thoroughly dried and the test then repeated. Drying out temperature of the winding should not exceed 80°C as measured by a thermometer.

K. To correct IR readings to the reference temperature, use the formula found in IEEE Std. 43-2000.

$$R_c = K_t \times R_t$$

Where:

R_c = Insulation resistance (in megohms) corrected to 40°C

R_t = Measured insulation resistance (in megohms) at temperature *t*

K_t = Insulation resistance temperature coefficient at temperature *t*

Obtain *K* from Figure 1 in IEEE Std. 43-2000.

Windings in apparently good condition should receive a dielectric, non-destructive, DC overpotential (Hipot) test on the armature and fields for 1 minute at a voltage T calculated as follows: (Hipot to be requoted by User):

$T = 0.65\,(2E_m + 1000\text{ V})(1.7)$ Volts — 460V = 2122 VDC; 750 V = 2763 VDC

Where: E_m = Rated motor nameplate voltage

L. If these tests are not passed, the Repair Facility should discuss the results with the User to arrive at a decision to rewind or to attempt further reconditioning and retesting.

M. Brushes and holders, commutators condition, cleanliness, laminations, windings, and rub marks are checked as in the field poles. Armature laminations should be checked for "coning" (separation of laminations, causing the length of the armature to be greater at the outer diameter than it is at the shaft).

N. Inspect the armature core structure itself carefully for evidence of severe corrosion, core shifting, local overheating of laminations, loose or broken material, core blocking, or rub marks. A Core Loss Test should be performed to evaluate the condition of the laminations.

O. Commutators – Bars must be securely held to the vee ring. Stripped commutators should be tested at a minimum 2500 VAC to ground. Test at 220 VAC between bars using a 25 watt 220 volt lamp in series. Commutators shall be turned, undercut, and polished to insure concentricity, a maximum total allowable run-out (dial indicator) is .002 inch. Undercutting will be done to a depth of 1/16 inch to 3/32 inch. All high mica should be removed.

8.2 – Mechanical

The mechanical condition appraisal should give particular attention to the following:

A. *Antifriction bearings* – Condition of lubricant; dirt, rust, or moisture; fretting corrosion; thermal discoloration; pitting or spalling of balls, rollers, fluting, or races; broken or missing retainers.

B. *Sleeve bearings* – Scoring or wiping of babbitt; integrity of any insulation furnished to block passage of bearing current (50 MΩ minimum IR is recommended; no temperature correction is needed; use megohmmeter with less than 500 V output); oil leakage; oil ring wear. Check forced-oil lubrication systems for blockage inside piping; presence of proper metering orifices in the system; proper pump operation.

C. *Shafts* – Straightness (NEMA MG 1-2003 Rev. 1-2004, Section 1, Part 4, Paragraph 4.11); cracks, corrosion; scoring or galling.

D. *Seals* – Rubbing or wear; leakage; glazing or hardening of felt or elastomeric materials.

E. *Gaskets* – Hardened, broken, or shifted parts; missing gaskets; evidence of lubricant or contaminant leakage passed a gasket.

F. *Fasteners and dowels* – Loose, missing, or broken parts.

G. *Frame or housing* – Corrosion; structural weld integrity; blocked drains, breathers, or ventilating air passages; paralleling of feet.

H. *Condition of accessories* – Space heaters, thermostats, etc.

I. *Bearing replacement* –

1. Replace all antifriction bearings after removal (except if advised differently by User). Record new bearing data on Motor Data Summary sheet.

2. Large expensive bearings, such as, spherical roller thrust bearings may be kept and inspected and reused at Users' discretion.
    a. Check for symptoms of shaft current flow
    b. Improper thrust loading
    c. Fatigue
    d. Lubrication failure
    e. Internal clearances

K. *Mounting feet flatness* (motor frame feet are to be flat within 0.005 inches. when placed on a flat reference surface). If motor frame feet are out of tolerance, re-machine to specification or 0.003″, whichever is smaller.

8.2.1 – Recondition

Recondition of Main, Commutating, and Compensating, Field Poles and Armature Core

A. All components' parts shall be thoroughly cleaned. Steam cleaning is the preferred method following by drying at 250 ^{0}F. Cleaning will continue until all vent slots are free of any obstruction which may interfere with proper cooling of the motor. Insertion of any metal object into ventilation passages of a stator is unacceptable under any circumstances.

B. Prior to the varnish application, the windings will be preheated to remove air and moisture and ensure thorough impregnation. Oven temperature must not exceed 290°F during the drying cycle for Class 155 or 180 insulation. Oven temperature must not exceed 250°F for Class 105 or 130 insulation and followed by drying at 250^{0}F.

C. Final Megohmmeter reading must exceed 10 megohms at room temperature. A reading below 10 megohms requires communications with the User.

D. The motor windings must be sealed. If these components are well sealed, no additional varnish is required. If sealing is required the "Dip and Bake" method is recommended. If this is not practical, the spray, flow or pan dipping can be used. If no varnish is required or the "Dip and Bake" method is not practical, the User must be contacted.

E. The assembly of the motors repaired under preventive maintenance should follow the normal repair specification for DC motors.

8.3 – Stripping and Cleaning

8.3.1 – Mechanical Method

When using the mechanical removal techniques, extra care should be exercised so as to not cause separation of the laminations while pulling the windings. When heat is used to soften insulation (as opposed to burning out in an oven), the flame must not be allowed to impinge on the laminations.

A. Coils should be formed from continuous lengths of properly sized and insulated magnet wire (to match nameplate criteria). Splices are not recommended in individual coils under normal circumstances.

B. Insertion of coils in slots should be done with care to avoid damage to the insulation or magnet wire.

C. Crossings of magnet wire within the slots should be held to a minimum on random-wound coils.

D. Insulation systems shall be classified as follows:

- *NEMA Class 105* – An insulation system (105°C temperature limit including a 40°C ambient or 65°C rise) that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting Class 105°C hot spot temperature specified in the temperature rise standard for the machine under consideration.

- *NEMA Class 130* – An insulation system (130°C temperature limit including a 40°C ambient or 90°C rise) that by experience or accepted test can be shown to have suitable thermal endurance when operating at the limiting Class 130°C temperature specified in the temperature rise standard for the machine under consideration.

- *NEMA Class 155* – An insulation system (155°C temperature limit including 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 155°C temperature specified in the temperature rise standard for the machine under consideration.

- *NEMA Class H* – An insulation system (180°C temperature limit including 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 180°C temperature specified in the temperature rise standard for the machine under consideration.

    1. Only Class 155, Class 180 or better insulating materials will be used for the following components:
        a. Slot insulation
        b. Magnet wire
        c. Coil / Winding insulation
        d. Wedges/middle wedges
        e. Sleeving (Acryliglass)
        f. Tie cord
        g. Varnish
        h. Lead Wire

    2. Motors nameplate Class 180 insulation will be rewound Class 180 in all respects.

    3. All components that constitute the insulation system will be compatible with each other.

H. Construction of Coils

1. Armature

    a. The armature coils are to be wound with insulated copper wire and formed to the required shape. Coils shall be checked for uniformity before taping and again before winding. The uninsulated coil is to be made as void free as possible, by filling with epoxy or polyester varnishes, brushed on and hot pressing operation to fully cure the slot position and maintain dimensions.

    b. All connections between coils, and commutator are to be soldered, silver soldered, brazed or TIG welded.

2. Field Coils and Interpole Coils
    Coils should be replaced in-kind, with special attention to wire size, number of turns, and insulation, which shall be Class 155 or 180, unless otherwise noted.

8.4.1 – Inspect and Removal of Field and Compensating Coils

A. Prior to disconnecting the wiring, make an accurate drawing showing the location of all poles, wiring, fan blades, and associated hardware. Use the motor manufacturer's connection and outline drawings when available.

B. Each pole piece and shim pack should be match marked to the motor shell to ensure that they are reassembled in the same location and in the same orientation. General practice is to number the poles in a clockwise sequence, while facing the commutator end, identifying Pole #1 nearest to the top vertical position.

C. When removing shims, they should be marked as to their pole location. The shim material should be noted, if more than one type of material is used, then each shim pack must be installed in the same location that it was removed. Replacement shims and bolts must be made of the same material as the ones removed from the motor.

8.5 – Replacement of Bearings and Restoration of Fits and Seals

A. *Removal of bearings* –Roller and ball bearings should be removed by using hydraulic presses or screw-drive bearing pulling equipment. Removal by hammering is not acceptable. When heat must be applied for removal, precautions are to be used to ensure that heating is concentric and that the shaft will not be heated unevenly, does not exceed 250°F, and the bearing should not be reinstalled.

B. *Reassembly of bearings* – Split sleeve bearings should be fitted to journals by "bluing and scraping" as in the following:

1. Bearing and journals must be measured with micrometer and compared to the manufacturer's tolerances. Both the bearing and journal are to be measured at three locations across the length; the locations for these readings are in the center of each and 1/4″ in from the ends. Also mic each at three locations around the surface, at the 12:00, 2:00 and 4:00 o'clock positions. These micrometer readings shall be recorded on Appendix F.

2. Using a bearing-scraping tool (typically a triangular file with the teeth ground off), scrape any side reliefs and lands to the clearances and contours recommended by the motor manufacturer. Apply a small amount of nondrying bluing compound to the shaft journal, spreading it out to form a uniform coating 1 to 2 inches wide over the full length of the bottom of the journal. Lift the shaft slightly, roll the lower bearing half into place, then lower the shaft onto it, ensuring that the normal armature weight is applied to the bearing. Turn the shaft 1/2 to 1 revolution. Lift the shaft again, and roll the lower bearing half out. A pattern of very light blue and dark blue areas will be seen on the bearing surface. These correspond to "**low**" and "**high**" portions of the bearing surface, respectively. Scrape the high spots to make the light/dark pattern uniform; the fitting process should be repeated with bluing as required until at least 80% contact has been achieved. When this is complete, leave the lower bearing half in place with the armature weight resting on it.

3. If the bearing halves are not within limits, according to the manufacturer's specifications, both bearing halves must be re-babbitted if too loose, or the top half of the bearing must be scraped if too tight.

4. Reassembly of horizontal or vertical tilting-pad or shoe bearings should follow whatever procedures the manufacturer prescribes. Unless supplied by the User, details of that procedure should be given to the User as part of the final repair report.

5. Ball or roller bearings should be fitted to shafts by heat-expanding the inner bearing race in accordance with the bearing manufacturer's recommendations, however, **not to exceed 250°F**, using an oil-bath heater or an induction heater. Care must be exercised when using an induction heater to ensure that heat is evenly applied to the bearings. Bearings must not be allowed to seize onto the shaft in a cocked position or before being fully seated up to the location shaft shoulder or retaining ring. For those motors in which the outer bearing race is the "tight-fitted" member (e.g., vibration screen drives), the bearing chamber is to be heat-expanded: the inner bearing race will be a slip fit on the shaft. Any pressure used to seat a tight-fitting bearing race shall be equally applied around that race.

6. Sealants should not be used to secure a bearing race against rotation. If the metal-to-metal fit between races and the shaft or bearing housing is not within design limits, the fits between the shaft and bearing inner race should be either bushed, sleeved, remachined, or chrome plated and machined to size. Journals should be machined to an RMS 63 or better. Metal spraying should be

avoided since it causes stress risers. Fits between the bearing outer race and the housing bore should be machined and welded, or bored and sleeved, whichever is most economical for the User.

7. Grease-lubricated bearing housings or chambers should be packed no more than 1/3 full, using grease approved by the User.

8. Either sleeve or antifriction bearings may be electrically insulated in some way to block the passage of damaging shaft currents originating within the machine's electromagnetic dissymmetry. The integrity of this insulation, as applied to the bearings themselves, should be tested during the reassembly process. (See Section 8.2.B.)

9. All accessories fitted to bearing assemblies shall be replaced so that bearing insulation is not short-circuited and so that no protective system sensitivity is lost. Such accessories include lubrication system piping and fittings as well as temperature or vibration sensing devices.

10. Bearing assemblies should be adjusted to provide total shaft end play in accordance with the machine's design limits. For horizontal shaft antifriction bearing motors, the end play must allow for thermal expansion of the shaft without damage to the bearings. For vertical motors, locknut adjustments, spacer rings, and installations of thrust bearing, support springs must be in accordance with the manufacturer's instructions (or User's specifications). Sleeve-bearing machines must be assembled by adjustment of bearing or armature positions such that the rotating assembly will "float" at its magnetic center position within the normal end play limits. This natural rest position will be indicated by the magnetic center indicator supplied on the motor, which should be carefully checked at reassembly. Any change in the magnetic center position, although it may be acceptable, must be marked on the shaft so as not to mislead the installer into positioning the coupling inappropriately.

11. Observe the bearing assembly for oil leaks with the system properly filled with oil. Repair all leaks as needed.

8.6 – Armature / Field Poles

8.6.1 – Lamination Repair of the Main and Commutating Field Poles, and Armature Core

A. Eliminate laminations with mechanical or electrical damage. The following four methods of repairing laminations in a DC motor are dependent on the degree of damage. Selection of a method is based on the inspector's experience and judgment as to which repair method will eliminate core hot spots. The User must approve complete new core assemblies. Replacement of field pole or armature core iron material shall be of the same type and thickness used in the original motor. Each lamination shall be well insulated from other laminations.

   1. *Method One*: (*Field Pole* is slightly rubbed by the armature, fusing the edges of the laminations together.) The effectiveness of this method depends on the depth of the slot and the extent to which the winding fills the slot. The fused laminations may be vibrated apart with an air-driven hammer placed against the end of the core section. Vibrations of the lamination fingers will break the metal fusion. Remove all sharp edges and burrs. While vibrating the damaged section, spray a high-quality insulation varnish in the damaged area. As the fingers vibrate, the varnish will penetrate the air gaps caused by the vibration and re-insulate the fingers. This method assumes the damage is near the end of the lamination core section and the damage is on the tips of the fingers. Alternately, the laminations can be separated and the interlaminar insulation can be restored by the insertion of varnished mica splittings followed by an overall varnish treatment.

2. *Method Two*: (Coil has failed in the slot, thereby melting the laminations, or the stator is moderately rubbed by the armature.) With a pencil metal grinder, grind away fused metal until a definition of core laminations can be seen. Small, high-speed (25 000 r/min) hand grinders equipped with carbide-tipped, cone-shaped rotary files work best. Grind with light, intermittent pressure (rather than continuously) with movement in the same plane as the laminations until the fused metal is removed. Repaint the ground area and test the core for hot spot in the damaged area. Do not grind an area that will damage the mechanical integrity of the slot. If the damaged area is more than 20% of the total surface area of the core, then go to Method Three.

3. *Method Three*: (Damage is greater than 20% of total core-surface area or hot spot cannot be eliminated by Method Two.) If the damaged area cannot be repaired by one of the first two methods, then a partial or total restacking of the field pole or armature core must be considered. The laminations will need to be disassembled and replaced or repaired by hammering and sanding away the damaged metal. The laminations must then be reinsulated by dipping in an organic insulating material with at least 300°C temperature rating and air drying before reassembly. Inorganic insulation with higher temperature ratings is preferred, if available. The damaged area can be redistributed in the core by rotation of each damaged lamination by one slot. This may require re-keying the lamination in the frame.

4. *Method Four*: Coning (flaring) of end laminations on armature cores should be fixed by welding to rigid laminations, installation of rigid finger plates, undercutting and banding, or lamination replacement. Excessive coning of the end laminations will often require replacement of the armature to achieve a satisfactory result. Vacuum-pressure impregnation (VPI) or varnish treatment shall not be used.

B. Armature / shaft assemblies should be lifted and handled carefully so as not to transmit any lifting or other stresses to any part of the armature cage or other motor windings. Lifting equipment must not cause abrasion or other physical damage to journal surfaces or seal fits. Do not allow the armature to drag against the inner diameter of the field poles when inserting the armature into the DC motor.

C. The armature should be located on the shaft per OEM or according to the original location. Armatures shall be keyed and/or shrunk to the shaft. Centering the armature within the motor shall be checked, whenever permitted by the machine construction, by both “stationary gap” and “rotating gap” feeler gage readings at both ends of the motor. Readings should be taken at not less than six points 60° apart around the armature periphery. In the “stationary” check, feeler gages are inserted successively at the separate points and the values are recorded. In the “rotating” check, the gages are left at one location and the armature is turned in 60° steps, noting the reading at each step. This test can reveal an eccentric armature that may go undetected by the “stationary” test. Record final air gap reading on Appendix B. Readings shall not exceed a 10% deviation from the average at each end according to the following formula.

$$D = [(H-L)/A]100$$

Where:
- D = percentage deviation
- H = highest of the readings at one end of the motor
- L = lowest of the readings at the same end of the motor
- A = average of the readings at the same end of the motor

D. Secure internal bolts, screws, and nuts by tack weld or bent tab keepers. Lock washers and liquid coatings, by themselves, are not acceptable.

9.0 - Balancing

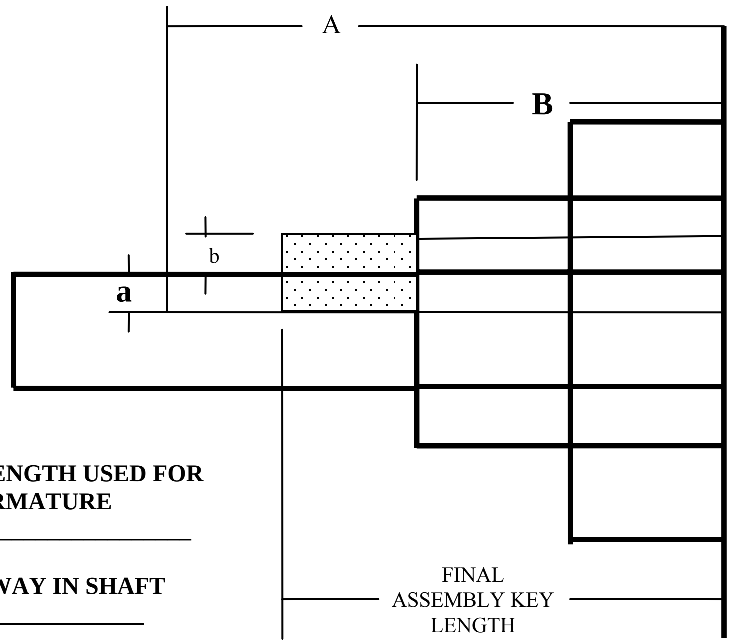
9.1.1 – Balancing – Shaft and Fitment Key Convention

9.1.1.1 – Standard Key

A. For rotating machines and machine components with a keyed shaft, this Standard requires balancing be achieved using a standard one-half key in the key seat in accordance with ISO 8821-1989(E). ISO 8821-1989(E) applies to armatures balanced in balancing machines, in their own housings, or in situ, and applies to keys of constant rectangular or square cross-section, keys mounted on tapered shaft surfaces, woodruff, gib, dowel and other special keys.

B. If a full key, corresponding to the half key used for balancing, is not provided with the rotating machine, a tag, as shown in Figure 1, will be attached to the machine indicating the dimensions of the key used to perform the balance test.

C. If no key is shipped with the shaft, and a tag is shown in Figure 1, is not attached to the shaft, the length of the half-key used originally for balancing the shaft is assumed to be the same as the length of the shaft keyway (Ref. ISO 9921).



A= "HALF KEY" LENGTH USED FOR BALANCING ARMATURE

A = ______________________________

a= DEPTH OF KEYWAY IN SHAFT

a= ___________________________

B= "HALF KEY" LENGTH USED FOR BALANCING THE FITMENT

B= __________________________

b= DEPTH OF KEYWAY IN FITMENT

b= ______________________________

FINAL ASSEMBLY KEY LENGTH = (A X a) + (B X b)

FINAL ASSEMBLY KEY LENGTH = ______________

ARMATURE ASSEMBLY S/N or other ID# ________________________________

FITMENT S/N or other ID# ____

____

Fig. 1 – **Balance Test Key Dimensions**

9.1.2 – Shop Balancing

A. Speed

- For the purposes of balancing, the greater of the maximum speed indicated on the motor nameplate or the actual maximum in service speed shall be referred to as the "in service" speed.

- Balancing shall occur at the highest practical rotating speed which does not exceed the in service speed nor place the rotating element within 25% of its critical speed.

B. Weights

- The use of solder or similar deposits to achieve armature balance is not acceptable. Any parent metal removed to achieve balance shall be drilled out in a manner which will maintain the structural integrity of the armature.

- The attachments of weights to the armature shall be done using non corrosive material and good practices to insure the integrity of the armature and the attachment.

- It is recommended that old weights be removed rather than applying new weights to oppose them.

C. Balance Methodology

- Armatures shall be supported in the balancing machine on the bearing fits if practical. If not practical, it is acceptable to support the armature close to the bearing fits provided that portion of the shaft is concentric within 0.0005″ TIR of the bearing fit.

- During balancing, all unused key seats will be filled with a standard half key or its equivalent as described in this document.

- All armatures and armatures with integral attachments will initially be balanced in at least two planes without external attachments installed to the shaft.

- If the armature is to be fitted with external attachments or fixtures (coupling hubs, brake wheels, etc.) when delivered to the User, it is recommended that these external attachments be fitted to the already balanced armature using a standard key as described in this document The armature assembly is then rebalanced with the primary correction plane(s) corresponding to the attachments or fixtures. If disassembly is necessary, these fixtures and keys must be marked so that they can be reassembled with the same mating parts in the same positions.

D. Balance Standard

- All armatures, armatures with integral attachments, and armature assemblies including external fixtures and attachments must comply with the API balancing standard and methodology at the in service speed. This standard states the maximum permissible residual imbalance per balance plane using the following formula.

  Uper = (4 x W)/N

  Where: Uper = Maximum permissible residual imbalance in that plane (ounce-inches)
  W = Weight supported by the balance machine at that journal (pounds)
  N = In service speed (RPM)
- Different balancing machines use different units and methodologies. Often, it is a matter of metric to English conversions, display in mils rather than ounce-inches or even conversions from balance standard RPM to actual balancing machine RPM. It is EXTREMELY important that each User and Repair Facility recognize these differences and compensate for them so that their results are truly representative of the balance quality and that they do comply with the balance standard. As a reference, the above API two plane balancing standard is approximately equivalent to an ISO 1940/1941 G0.67 balance grade.

E. Balance Report

A copy of the report from the final run of the armature or armature with integral attachments as well as a copy of the report from the final run of the armature assembly will be supplied to the User. At a mimimum, the reports should identify the armature, motor, and job, indicate the date and time of the run, armature weight on each journal, in service speed of the armature, balancing speed, the make and model of balancing equipment used, the calculated acceptance limit based on the above balance standard, and the final balance readings. See Appendix H.

10.0 – Electrical Connection

A. Unless otherwise specified, original number of leads will be brought out on all motor rewinds. All external leads will be flexible and in good condition. The leads will be sufficient length to permit easy connection outside of conduit box. Where any cables pass across or against metal edges of motor structural parts in the assembled machine, cable should be appropriately sleeved or taped for mechanical protection of the insulation against abrasion.

B. All leads should be given permanent markings adjacent to the terminal lugs in the form of indented metal bands (unless permanently die-stamped into the cable insulation or approved equivalent). Lead identification should be in accordance with NEMA MG 1-2003. Rev. 1-2004, Section 1, Part 2.

C. Lead cables should not be brazed or welded to terminal lugs. The preferred method of attachment is by crimping or pressure indenting the lug barrel, using a lug sized to suit the particular cable stranding provided, in accordance with recommendations of the lug manufacturer. No split barrel lugs are to be used. The crimping tool used should have ratchet pressure control such that the tool cannot be opened and released from the lug until the minimum recommended crimping force has been applied. Whenever possible, one cable should be crimped within the barrel of any one lug. In no case shall any strands of cable be cut or bent back out of the lug barrel so as to more easily fit the cable into the barrel. All strands must be fully attached to the lug.

D. Any bolted joints in the lead connections, such as where two or more lugs are permanently joined together or where bus bars are interconnected in some large machines, should be tightened to the following minimum torque values (based on heat-treated, Grade 5.0 steel bolts having non-lubricated threads):

Bolt size (in)	Minimum dry tightening torque (lb.-ft)
1/4	11.00
5/16	21.00
3/8	38.00
1/2	85.00
5/8	175.00

11.0 – Fits

A. All parts containing machined fits – bearing brackets, frame structures, bearing capsules or holders, etc. – should be handled in such a way as to avoid distorting or scarring any of the machined surfaces. Any such fits should be thoroughly cleaned before being reassembled to a mating part. Take care to avoid getting a fit "cocked", and be sure parts are fully seated against any locating shoulders.

B. All shaft attachments such as brake wheels and coupling hubs shall be concentric with the shaft centerline of rotation. Coupling hubs shall be concentric within the greater of 0.001″ TIR or 0.0002″ TIR per inch of shaft diameter. Brake wheels shall be concentric within 0.005″ on the diameter.

C. Gaskets should be replaced with materials appropriate to the motor's in-service environment. Sealing compounds used in lieu of gasketing should be applied in adequate thickness to fully seal the opening and should be of a consistency such as to remain in place after assembly. If RTV sealant is used, it must be electrically compatible with the commutator and brushes.

D. Any dowel pins supplied between mating parts are to be properly replaced. Tightness of mounting bolts, or any sort of sealing compound is not to be relied upon to maintain part alignment.

E. Some large motors may require shims to adjust field pole position for correct air gap or to control bearing pedestal position. Shims used for that purpose must be flat, clean, free from burrs, and either stepped or tapered as necessary to accommodate surfaces that may not be parallel.

12.0 – Assembly

1. All assembly will be according to Professional Quality Shop Practices.

2. If the shaft requires replacement, a new shaft will be made of A.I.S.I. 4140 Steel HRHT (Hot Rolled Heat Treated). Under special cases shaft material will be replaced with 316 stainless or User-approved materials.

3. Motors will be assembled in a manner that will ensure proper fit and alignment.

4. Check and record air gap on Appendix B (Section 8.6.1.C).

5. All bolts, nuts, etc., will be replaced as required with SAE grade 5 or better and torqued to industry standards. On metric fasteners use a grade 8.8 (old grade=8G) or better.

6. All assembled components will be checked to ensure secure fits.

7. All covers on openings in the frames or housings must be fastened in a closed position.

8. Motor terminals must be identified outside the motor frames.

9. New brushes will be installed on all motors.

    A. Replacement brushes will be made in kind.

    B. Brushes will be properly seated to ensure proper commutation. Brush holders will be reconditioned or replaced as required.

    C. Brush pressure springs will be checked and recorded in lb./sq. in. to ensure equal loading on all brushes (Appendix F).

10. Replacement cooling fans on armatures shall be of the same type or better than the original fan.

11. All broken, burned or cracked motor feet shall be weld repaired and machined to within .003″ (Section 8.2.J) of parallel and flatness.

12. All motors will be returned with an adequately sized conduit box and cover with a gasket between the box and cover.

13. A repair ID tag will be added, name of Repair Facility, ID# and date of repair.

14. After painting, all nameplates, tags and shaft will be fully cleaned. A non-silicon rust inhibitor or light oil will be applied to the shaft before shipping.

13.0 – Run Test Standards

A. Run test shall be a minimum of 45 minutes duration at the rated nameplate RPM until the temperature of the bearings have stabilized (+/- 1°C over 15 minutes). A maximum temperature of 150°F on babbitt bearings shall not be exceeded (unless bearing the manufacturer specifies. otherwise). On anti-friction bearings and on motors with a cooling fan the bearing housing temperature should not exceed 30°F above ambient temperature for oil lubrication, and 50°F above ambient for grease lubrication. On motors without external cooling fans, the bearing housing temperature should not exceed 50°F above ambient. At no time should the temperature exceed the drop test temperature of the lubricant.

B. Commutator and Brushes – While the machine is running, visually inspect for sparking at the brushes. Listen for brush chatter or brush clicks. These noises indicate rough spots or a step in the commutator surface. All abnormalities shall be corrected prior to shipment and subjected to the User's final acceptance. A written record of all tests and inspection results will be furnished to the User upon completion of repairs.

13.1 – Vibration Acceptance Testing on Motors

13.2 – Quotation

A. The quotation for repair or supply of a motor shall specify that the motor will meet or exceed the vibration limits described in this document.

B. The quotation will reiterate the vibration acceptance levels for the particular motor as defined in this document and requested by the User.

C. Any additional costs required to meet these vibration acceptance limits will be grouped separately on the quotation, itemized in sufficient detail as to permit evaluation by the User. This grouping will be titled "Vibration Limits".

13.3 – "As Found" Tests

A. The "As Found" run test should be reviewed with the User on an as needed basis.

B. DC Shunt motor (single speed) – Apply rated current to the field circuit. Then, from a separate source, gradually apply full rated armature voltage. This, in turn, will yield full no load speed.

C. DC Series Motor –Using a low voltage, high current source, separately excite the series field circuit to provide for its operation as a shunt motor. When, and as able, apply full series field current (i.e., rated load current) to simulate full no load speed. With the series field current adjusted in this manner, gradually increase armature voltage to full nameplate rating and allow the motor to slowly reach no load speed.

D. DC Compound Motor – Set the source for each field circuit to provide normal field current. Then slowly increase armature voltage and allow the motor to come to no load speed.

Note: Series motors cannot be run at the no-load, full voltage/current condition. Care must be exercised with compound motors depending on the amount of series influence. These motors must be run at reduced voltage/current to prevent catastrophic failure.

E. The "As Found" tests will consist of the same suite of measurements as the "Acceptance Tests", but will not be gauged against the acceptance criteria.

F. Motor isolation in the form of a mounting plate and resilient support pads is not required during the "As Found" tests.

G. All unused keyways shall be fitted with a standard or equivalent half key as described in the Standard Key section of this document (Section 9.1.1.1).

13.4 – Acceptance Tests

A. The "Acceptance Test" will be conducted after the machine has achieved thermal stability. In the case of series motors, "Acceptance Test" may be performed at reduced voltage, at near full speed, under no load, and after the machine has achieved thermal stability and approved by the User. Follow the "As Found" test procedures for testing.

B. If the machine is to be delivered with a coupling or other fittings installed to the rotating component, these tests shall be done with those items installed. If these fittings are keyed to the shaft, a standard key shall be used.

C. All unused keyways shall be fitted with a standard, or equivalent half key as described in the Standard Key section of this document (Section 9.1.1.1).

D. After reaching the rated no load speed, check to see that the shaft is turning smoothly in its bearings and that there are no abnormal sounds.

E. Verify that all shaft-mounted blowers are turning in the proper direction.

F. Verify that oil lubricated bearings are being properly lubricated and that oil rings, when present, are free and turning.

G. Dress commutators with a suitable grade of dressing stone. (This helps to remove small burrs caused by the beveling operation and complete seating of the brushes.)

Note: Use caution to avoid any copper dust buildup that could result in a flashover of the brush holders or dressing stone. Clear dust away with dry low pressure air.

H. Check for satisfactory commutation. There should be no sign of sparking when running at no load. When necessary, de-energize and electrically reset the brush assembly to neutral (Bucking Field/Interpole).

Note: It is particularly useful to observe commutation as the motor accelerates since the brushes carry a larger current during the period. Should sparking occur, one of the most common reasons is a reversed connection between the brush assembly and the commutation leads.

13.5 – Responsibility

A. The Repair Facility shall be responsible for all aspects of test preparation, testing, presentation of results, and long-term storage of the results unless otherwise specified by the User.

B. The testing shall be done in manner consistent with good vibration data collection practices using instrumentation that is in good condition to insure accurate, reliable results and shall be performed by ISO 1836-2 category 2 or higher certified persons. Testing by non-certified persons may be acceptable if they are working under the direct supervision of an ISO 1836-2 category 3 certified person.

C. The testing shall be done at the Repair Facility. If this is impractical, the User may approve other arrangements. In no case will the site of testing relieve the repair of responsibility for passing the vibration Acceptance Tests.

D. The User shall have the option of being present during vibration testing and verifying testing performed by the Repair Facility prior to final acceptance by the User.

E. The Repair Facility will maintain measurement results of all vibration tests in electronic (preferred) or hardcopy form for a minimum of 15 years. Make, model, serial number, User number, repair/purchase order number, and date shall be used to index these sets of vibration results.

F. Measurement results according to paragraphs. G and H of this section will be conveyed to the User in a format acceptable to the User. The format may be hardcopy, electronic transfer, MIMOSA Data Exchange format, or other electronic format acceptable to the User.

G. "As Found" vibration test results will include:

1. Frequency domain (spectrum) plots across the frequency ranges of interest,
2. A tabular representation of maximum line amplitude measures in inches/second peak for each frequency band and location, and
3. A tabular representation of the maximum band limited overall amplitude in G's peak for each frequency band and location.

H. Post Repair Acceptance Test results will include:

1. Frequency domain (spectrum) plots across the frequency ranges of interest,
2. A tabular representation of maximum line amplitude measures in inches/seconds peak for each frequency band and location,
3. A tabular representation of the maximum band limited overall amplitude in G's peak for each frequency band and location, and
4. A tabular representation of the maximum allowable vibration limits for both 3 and 4.

I. A signed statement of adherence to the testing methods and compliance with the vibration acceptance levels must accompany the post repair results to the User before motor acceptance will be authorized

13.6 – Instrumentation Requirements

A. Instrument Capability and Settings

1. The instrument will be capable of driving acceleration transducers directly, of integrating acceleration to velocity in either the analog or digital realms, of digitizing the analog vibration signal, of and performing FFT processing to the frequency domain (rather than utilizing a swept or tunable filter to derive frequency components).

2. The instrument will have at least 72dB of effective dynamic range.

3. The instrument will utilize appropriate anti-aliasing filters for all measurements.

4. The instrument will be capable of at least 400 usable FFT lines of resolution, however no more than 800 FFT lines will be used for any measurement. Additional measurements across lower frequency ranges may be necessary to adequately resolve signals down to 0.3x running speed.

5. The instrument will be able to apply a Hanning window during FFT processing. This Hanning window will be used with all FFT measurements.

6. The instrument will be capable of linear averaging in the frequency domain. A minimum of 4 averages with no overlap processing or 6 averages with overlap processing is required. No more that 16 averages will be used for any measurement.

7. If overlap processing is available in the instrument, no more that 50% overlap will be used.

8. If used, high pass filtering (low frequency cutoff) settings will not filter out frequencies of interest.

13.7 – Transducer and Mounting

A. Transducers will be of the "industrial" style and measure acceleration.

B. The transducer nominal sensitivity will be 50mV/g, 100 mV/g, or 500 mV/g.

C. The transducer calibration value will be within +/– 10% of nominal at 100 Hz.

D. The transducer output will be linear, within +/– 5%, from 0.3x running speed through 2000 Hz.

E. The transducer will be mounted to the machine under test using a 2-shoe magnet, flat magnet, or stud mounting. During acceptance testing, the mounting locations shall be smooth, clean, and free of debris or paint. During "as found" testing, the mounting locations shall be clean and finished such that the mounting is firm, not rocking. The use of a handheld probe mounting is not acceptable.

A. The mounted natural frequency of the transducer and magnet must exceed 2000 Hz by at least 30%. In the case of triaxial transducers, the mounted natural frequency of the transducer and magnet in all three planes must exceed 2000 Hz by at least 30%.

G. The transducer electronics must be isolated from case and ground.

H. The measurement system used to take vibration measurements (instrument, cable, transducer, and mounting) shall have a +/- 5% amplitude accuracy between 0.3x running speed and 2000 Hz.

13.8 – Test Locations

A. Horizontal shaft motors

1. A minimum of 6 separate locations on each motor will be tested. These locations shall be as close as practical to each bearing.
2. Each bearing will have a radial measurement made in the horizontal direction, facing the centerline of the shaft. These will be described using the conventions

MTR OB HOR and MTR IB HOR or
MTR ODE HOR and MTR DE HOR

3. Each bearing will have a radial measurement made in the vertical direction, facing the centerline of the shaft. These will be described using the conventions

   MTR OB VER and MTR IB VER or
   MTR ODE VER and MTR DE VER

4. Each bearing will have an axial (parallel to the shaft) measurement made. This axial measurement should be as close to the shaft as practical and located at the 12:00 o'clock position. These will be described using the conventions

   MTR OB AXL and MTR IB AXL or
   MTR ODE AXL and MTR DE AXL

   TEFC or other shrouded machines may make it difficult to get close to the shaft. In those cases, a foot type measurement is acceptable and should be noted with the results.

5. Measurements cannot be made on sheet metal covers, fan shrouds, or other parts whose position, natural frequency, or damping will significantly affect the measured vibration.

B. Vertical and Non-horizontal shaft motors

1. A minimum of 6 separate locations on each motor will be tested. These locations shall be as close as practical to each bearing.

2. Each bearing will have a radial measurement made inline with the direction of the "Point of Energy Input" (typically the junction box), facing the centerline of the shaft. These will be described using the conventions

   MTR OB INL and MTR IB INL or
   MTR ODE INL and MTR DE INL

3. Each bearing will have a radial measurement made perpendicular to the direction of the "Point of Energy Input" (typically the junction box), facing the centerline of the shaft. These will be described using the conventions

   MTR OB PER and MTR IB PER or
   MTR ODE PER and MTR DE PER

4. Each bearing will have an axial (parallel to the shaft) measurement made. This axial measurement should be as close to the shaft as practical and located either in the center of the end bell or offset to the "Point of Energy Input" (typically the junction box. These will be described using the conventions

   MTR OB AXL and MTR IB AXL or
   MTR ODE AXL and MTR DE AXL

   TEFC motors, shrouded machines, or mounting in the test stand may make it difficult to get close to the shaft. In those cases, a peripheral axial measurement is acceptable and should be noted with the results.

5. Measurements must be made on a rigid portion of the machine. They cannot be made on sheet metal covers, fan shrouds, or other parts whose position, natural frequency, or damping will significantly affect the measured vibration.

13.9 – Technical Details

Acceptable Units

1. Frequency	Hertz
2. Rotational Speed	RPS (revolutions per second) or RPM (revolutions per minute)
3. Vibration Displacement	Mil Peak to Peak (1 Mil = 0.001″)
4. Vibration Velocity	IPS Peak (Inches per second)
5. Vibration Acceleration	G Peak (G is acceleration of gravity)

13.9.1 – RMS vs. Peak Types

A. The FFT process by definition produces only RMS (root mean square) amplitude values. These tests **do not require** the display of RMS values.

B. The Peak amplitude values are derived from the RMS FFT values based on the simple equation: Peak (P) = 1.414 x RMS value. This **Peak** amplitude type **is required for these tests**.

C. The Peak-to-Peak amplitude values are derived from the RMS FFT values based on the simple equation Peak (P) = 2 x 1.414 x RMS value. This Peak-to-Peak amplitude type is **not required** for these tests.

D. The true Peak amplitude value must be derived from the time domain. It is the magnitude of the most extreme excursion from “zero” within a time block. This amplitude type is **not required** for these tests.

E. The true Peak-to-Peak amplitude value must be derived from the time domain. It is the difference between the most negative observed value and the most positive observed value within a time block. This amplitude type is **not required** for these tests.

13.10 – Frequency Bands

A. The frequency range of a measurement will be divided into subgroups called Bands. The Fmin and Fmax will be defined in terms of order of running speed or in absolute frequency units.

B. If a line of resolution falls upon the Fmin of one band and the Fmax of another band, it is included in both bands.

C. The Bands may or may not overlap.

D. Acceptance criteria will be associated to the vibration peaks (Line Amplitude) or power Band-Limited (Overall Amplitude) within each band.

13.11 – Line Amplitude Acceptance Limits

A. Line Amplitude Acceptance Limits are applicable to bands of any width.

B. The “Line Amplitude” is the magnitude of the single FFT line or cell at that frequency or line of resolution. Effectively, it is the RMS power contained in one frequency bin.

C. The magnitude of all lines within a band must not exceed the Line Amplitude Acceptance Limit for that band.

13.12 – Band-Limited Overall Amplitude Acceptance Limits

A. Band-Limited Overall Amplitude Acceptance Limits are only applicable to bands that are at least 5 lines of resolution in width.

B. The “Band-Limited Overall Amplitude” is the overall vibration contained within that band. It can be calculated using the following formula. Please note that many software manufacturers that offer frequency banding and “power within band” as an option utilize equivalent calculations. This should be verified with your software manufacturer before use.

$$BLOA = \sqrt{\frac{\sum_{i=1}^{N} A^2{}_i}{LS}}$$

Where:

BLOA =	Band Limited Overall Amplitude
A_I =	Amplitude of the i^{th} line of resolution
(I=1) =	The first line of resolution in the band
(I=N) =	The last line of resolution in the band
N =	The number of lines of resolution in the band
LS =	Line Shape Factor (1.5 for Hanning Window)

C. The calculated Band-Limited Overall Amplitude of a band must not exceed the Band-Limited Overall Amplitude Acceptance Limits for that band.

13.13 – Motor Mounting for Testing

Base Plates

1). Motors that do not use resilient mounting in service will utilize a steel or aluminum base plate of substantial stiffness during testing.

2). The base plate must not exceed 5% the mass of the motor.

3). The motor must not rock on the plate; a soft foot must be eliminated.

4). The linear dimension of the base plate will at least equal, but not exceed, the projected motor base by more than the greater 10% or 4 inches.

5). While testing, the motor shall be positioned on the base plate to provide uniform compression of the support pads.

13.13.1 – Cradles for Flange Mounted Non-Vertical Motors

A. Flange mounted motors shall be mounted to a cradle to simulate their in-service orientation.

B. The base of the cradle will be flat and sized as a base plate for a like frame size foot mounted motor.

C. The mass of the cradle and its base must be no more than 10% of the mass of the motor under test.

13.13.2 – Cradles and Adapter Plates for Vertical Motors

A. Vertical shaft motors will require the use of a cradle or adapter plate to support the motor in a vertical orientation. These fixtures must support the motor in the in service orientation to mimic their in service mounting.

B. If used, the adapter plate shall be fixed to the mounting flange of the motor under test. The motor must be centered in the adapter plate.

C. If a cradle is used, the motor must rest securely, without rocking in the cradle. Fastening the motor to the cradle is acceptable and suggested.

D. The cradle or adapter plate shall not exceed the dimensions of the motor flange by more than 6 inches.

E. The mass of the cradle or adapter plate must be no more than 5% of the mass of the motor.

F. Extra care must be taken to secure vertical machines in a safe manner during testing.

13.13.3 – Support Pads

A. Resilient support pads can be used to support the motor, the motor sitting on a base plate, the motor attached to the cradle with base plate, the motor sitting on the vertical cradle, or the motor attached to the vertical adapter plate.

B. If used, resilient support pads shall support the entire base plate area. The pad shall not be more than 10% larger than the base plate.

C. Resilient support pads must be selected such that when the motor and auxiliary mounting fixtures (if any) are placed upon the support pads, they do not rock and the up-and-down natural frequency is less than 25% of the test speed of the motor.

D. Resilient support pad thickness shall be such that the downward deflection of the pad due to the static load of the motor and support plate (if used) shall not be more than 50% of the original pad thickness. The deflection must be at least that calculated with the formula

Deflection (inches) = $(900/RPM)^2$ or the values in the table below.

Motor Speed (RPM)	Minimum Deflection
0 to 720	1.56”
721 to 900	1.00”
901 to 1200	0.56”
1201 to 1800	0.25”
1080 to 3600	0.06”

E. For any motor to be tested, the necessary thickness of the resilient pad can be calculated from the following formula:

$$T = KDA/F$$

Where:
- T = Pad thickness (inches)
- K = Modulus of elasticity (lbs. per square inch)
- D = Deflection required (inches)
- A = Area of contact between pad and base/feet
- F = Weight of motor and fixture

13.13.4 – Foot Mounted Horizontal Shaft Motors

A. Select an appropriate base plate for the motor. Select and place the appropriate support pads on a flat horizontal test surface. Place the base plate on the support pads. Place and center the motor on the base plate. The motor shaft must remain relatively horizontal. Reposition the pads, base plate, or motor to obtain a stable test environment.

B. If the motor is to be resiliently mounted while in service, omit the base plate. Select and place the appropriate support pads on a flat horizontal test surface. Place the motor on the support pads. The motor shaft must remain relatively horizontal. Reposition the pads and motor to obtain a stable test environment.

13.13.5 – Flange Mounted Non-Vertical Shaft Motors

A. Attach the flange of the motor to an appropriate cradle with integral base plate. Select and place the appropriate support pads on a flat horizontal test surface. Place the motor and cradle with integral base plate on the support pads. The motor shaft must remain positioned in its in service orientation. Reposition the pads, base plate, or motor to obtain a stable test environment.

13.13.6 – Flange Mounted Vertical Shaft Motors (Cradle)

A. Select the appropriate cradle and attach it to the motor flange if needed. Select and place the appropriate support pads on a flat horizontal test surface, table, or structure. Place the cradle on the support pads. Place the motor flange onto the cradle, if not already attached. The motor shaft must be relatively vertical and in the "in service" orientation. Reposition the pads, cradle, or motor to obtain a stable test environment.

13.13.7 – Flange Mounted Vertical Shaft Motors (Adapter Plate)

A. Attach the flange of the motor to the appropriate adapter plate. Select and place the appropriate support pads on a flat horizontal test surface, table, or structure. Place the motor and adapter plate on the support pads. The motor shaft must be vertical and in the "in service" orientation. Reposition the pads or motor/plate to obtain a stable test environment.

13.13.8 – Other Mounting and Setup Recommendations

A. Use a test table surface or structure, which is of substantial construction, and free from vibration.

B. Place the proper resilient pads on the test surface.

C. As required, place the base fixture (if separate) on the pads.

D. Place the motor squarely on the fixture so that the fixture is reasonably level, within +/- 0.125 inches.

E. Unless otherwise specified, fit the shaft keyway with a standard half key, secured by tape or other suitable means.

F. Safety is always a concern. Steady larger machines and vertical machines during startup to avoid the danger of being overturned or otherwise becoming unstable. Relax stabilizing fixtures while testing so as not to alter the test results.

13.14 – Acceptance Limits

A. The maximum Line Amplitude of vibration in each band in all directions shall not exceed those listed below for motors under no external load operating at 675 RPM or faster:

Band	Frequency Range	Standard Motor
1	(0.3 – 0.8) x Running Speed	0.05 inch/second peak
2	(0.8 – 1.2) x Running Speed	0.08 inch/second peak
3	(1.2 – 3.5) x Running Speed	0.05 inch/second peak
4	(3.5 – 8.5) x Running Speed	0.03 inch/second peak
5	8.5 x Running Speed – 1000 Hz	0.03 inch/second peak
6	1000 Hz – 2000 Hz	0.03 inch/second peak

B. The maximum band limited overall vibration in each band in all directions shall not exceed those listed below for motors under no external load operating at 675 RPM or faster:

Band	Frequency Range	Standard Motor
1	0.3 x Running Speed – 5000 Hz	0.8 g's peak

13.15 – Standard Keys

A. For vibration testing and balancing purposes, a "half" key must be secured in the unused key seat(s) on the rotating component. Upon assembly of keyed parts to the shaft, a standard key will be used unless requested otherwise by the User. For those cases where the key design or style does not fit the standard conventions, special consideration must be employed to follow the intent of the standard "half" key and standard key as referenced in Section 9.1.1.1.

14.0 – Painting

A. All accessible bare metal surfaces (including weld beads applied during repair) should be thoroughly cleaned and prime painted. Unless the User specifies otherwise, the Repair Facility can choose finish paint. Provide and mark a clean area for vibration probes as required.

B. Exposed machined surfaces (such as shaft extensions) should be coated with a rust-preventive coating unless the machine is to be returned to service immediately. Areas for vibration probes will be clean.

15.0 – Final Inspection and Shipping Preparations

1. Visually inspect the shaft, keyway, junction boxes and motor exterior for any defect or abnormality.
2. Check for lead identification as per the incoming markings.
3. Make sure the nameplate is complete and legible. If no nameplate exists a new one must be completed and attached to the motor.
4. On motors with sleeve bearings, the shaft must be blocked to prevent vertical and axial movements while in transit.

16.0 – Shipping Precautions

A. For either railcar or highway truck transportation, armature/shaft assemblies of sleeve-bearing motors should be blocked for shipment. All oil is drained from bearing housing and tagged "ADD OIL BEFORE STARTUP". The shaft should be restrained against either endwise, sidewise, or up-and-down movement caused by impact. Screws, clamps, plates, or other blocking means should be clearly identified for removal before the motor is started.

B. Vertical-shaft motors or motors having antifriction bearings need not be blocked for shipment provided one bearing is "fixed" as part of the normal assembly. Vertical motors are to be shipped in the vertical position.

C. Motors having antifriction bearings need not be blocked for shipment provided one bearing is "fixed" as part of the normal assembly.

17.0– Field Repairs

A. Although this recommended practice is intended to apply to repairs that are accomplished in a repair facility, it is recognized that repairs can and will be made at the installation location. For those cases, not all of the clauses of this document will apply. Others, however, should still be required. These can be handled on a job-by-job basis through communication between the User and Repair Facility.

Appendix A DC MOTOR INCOMING CHECK LIST

CUSTOMER _________________ JOB # .______________________

EMPLOYEE NO._______ DATE _______________________

1. READ THIS MOTOR SPEC ENTIRELY. REFER TO PARS 6.0, 6.1, &7.1 AND ALL OF THEIR REFERENCES.
2. GENERAL INPECTION – RECORD COMMENTS INCLUDING PHOTOGRAPHS
3. RECORD MOTOR NAMEPLATE DATA IN APPENDIX E.
4. INSULATION TESTS – RECORD RESLUTS IN APPENDIX B.
5. VERIFY MOTOR HAS LUBRICATION.
6. SPIN SHAFT AND CHECK TIR RUNOUT RECORD DATA IN APPENDIX B.
7. RESISTANCE COLD (RECORD). SHUNT FLD_________ ARM_________ COMP________ COMM________
8. ARMATURE AIR GAP AND END PLAY – RECORD RESULTS IN APPENDIX B.
9. IF ABOVE TESTS O.K. RUN MOTOR GRADUALLY UP TO TOP RPM; NO-LOAD AND RECORD DATA.

ARM VOLTS_______________ RPM_____________ ARM AMPS____________ SHUNT FLD AMPS _______

BRG.TEMP__________PE_______OPE RECORD VIBRATION DATA PER PARS 13.5.F &13.5.G

10. RECORD AND REMOVE COUPLING, IF NEEDED.
11. DISASSEMBLE MOTOR PER PARS 7.0,7.1, &7.1.1.
12. IF THE MOTOR HAS HEATERS, RECORD NAMEPLATE DATA, & DRAW A WIRING DIAGRAM
13. IF THE MOTOR HAS A BLOWER, RECORD NAMEPLATE DATA, & DRAW A WIRING DIAGRAM.
14. CHECK ALL BEARING SIZES, FITS, AND RECORD ALL NUMBERS IN APPENDIX C.
15. RECORD ALL BROKEN BOLTS, T-BOXES, EYE BOLTS, AND ANY OTHER VISUAL PROBLEMS THAT ARE SEEN ON THE MOTOR.
16. RECORD AS FOUND LOCATIONS FOR ALL SPACERS, SNAP-RINGS, AND SEALS.
17. PUT ALUMINUM TAGS ON LEADS BEFORE STEAM/BAKE.
18. NOTE ON JOB SHEET IF THE WINDINGS ARE FLARED, LENGTH OF COIL EXTENSIONS, LEAD NUMBERS, AND IF THERE IS INTERNAL AIR SHIELDS, AND FANS.
19. STAMP JOB NUMBER BY NAME PLATE OR ON A FLAT SPOT BY THE EYE BOLT.
    FOR THE ARMATURE, STAMP NUMBER ON END OF SHAFT - (OPE END)

16. CHECK AND RECORD RESISTANCES OF ALL TEMPERATURE SENSORS, RTD'S AND HEATERS.

NOTES ____

SUPERVISOR____DATE________________________

Appendix B **MOTOR DATA SUMMARY**

Customer ____________________ JOB# ____________________

Motor ID Tag # ____________________ Date received ____________________

Serial Number ____________________ Shop ID number ____________________

Temperature ______________ Humidity ______________

Shunt Field AC Pole Drop test passed ____________ failed ____________

Shunt Field DC Pole Drop test passed____________ failed ____________

Armature Windings Surge test passed ____________ failed ____________

Commutating Windings DC drop testpassed ____________ failed ____________

Compensating Windings DC drop test passed ____________ failed ____________

Polarity test-Bar to Bar passed ____________ failed ____________ ______

Tester initials

Insulation

	Before					**After**				
	Shunt Fld	Series Fld	Field-Arm	Field-Field	Arm-Grd	Shunt Fld	Series Fld	Field-Arm	Field-Field	Arm-Grd
Voltage										
Megohms										
Microamps										

Init.____ Init.____

	Drive-end Bearing		Opposite drive-end Bearing	
	Found	Left	Found	Left
Bearing size				
Shaft size				
Mfgr.				
Model #				
# Balls/Rollers				

Init._____ Init._____

Armature Air Gap & End Play

	Before		After	
	Opp. drive end	Drive end	Opp. Drive end	Drive end
Vertical 0°/180°	/	/	/	/
60°/240°	/	/	/	/
120°/300°	/	/	/	/
# Armature Bars				

Init. ______ Init._____

Cause of Failure/Notes/Comments: (APPENDIX B-1)______________________________

____

Appendix B-1 DC MOTORS

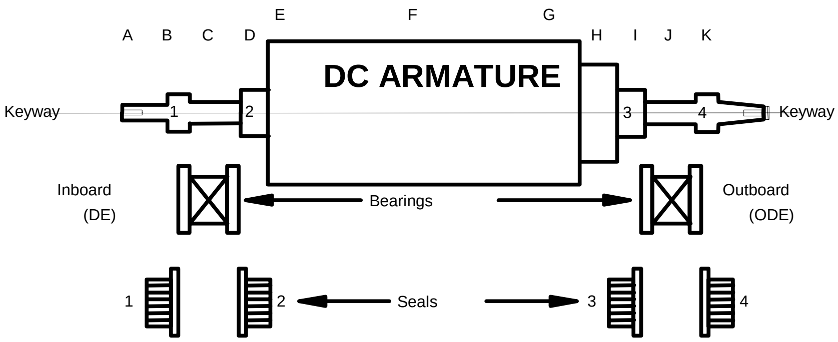
FAILURE ANALYSIS CAUSES

01. MISALIGNMENT
02. COUPLING DEFECTIVE
03. BRAKE WHEEL DEFECTIVE
04. DAMAGED SHAFT
05. FRAME DAMAGED
06. BROKEN OR MISSING FEET
07. WET
08. EXCESSIVELY DIRTY
09. FIELD COILS SHORTED
10. FIELD COILS GROUNDED
11. SHORTED OR GROUNDED ARMATURE
12. LAMINATIONS LOOSE
13. EXCESSIVE VIBRATIONS
14. ARMATURE DAMAGED
15. STALLED
16. ARMATURE LAMINATIONS DAMAGED/LOOSE
17. COMMUTATOR DAMAGED
18. ARMATURE OUT OF BALANCE
19. BRUSHES SHORT/DAMAGED
20. LAMINATION DAMAGE
21. OVERLOADED
24. BEARING FAILURE – DEFECTIVE BEARINGS
25. BEARING FAILURE – AGE (FATIGUE)
26. PULLED FOR PREVENTIVE MAINTENANCE
27. DAMAGED BRUSH HOLDERS
28. DAMAGED ARMATURE RINGS
29. DAMAGED LEADS
22. BEARING FAILURE – EXCESSIVE LUBRICATION
23. BEARING FAILURE – INSUFFICIENT LUBRICATION
30. DAMAGED GEARS

MECHANICAL INSPECTION FOR DC MOTORS AS RECEIVED

CUSTOMER ___________

RUN OUT POSITIONS



Job # ____________
MFR. ____________
RPM ________ HP ____
SERIAL # __________

DIAMETER & TOTAL INDICATED RUNOUTS

DIAGRAM POSITION

		DIA	TIR
OUTPUT	**A**	________	______
OUTER SEAL AREA	**B**	________	______
BEARING FIT	**C**	________	______
INNER SEAL AREA	**D**	________	______
ARMATURE BODY	**E**	________	______
ARMATURE BODY	**F**	________	______
ARAMTURE BODY	**G**	________	______
COMMUNTATOR	**H**	_______	______
INNER SEAL AREA	**I**	_______	______
BEARING FIT	**J**	________	______
AUX. OUTPUT	**K**	_______	______

KEYWAY DIMENSIONS

"A" OUTPUT:WIDTH____LENGTH_____DEPTH_____RADIUS__
"K" OUTPUT:WIDTH____LENGTH_____DEPTH_____RADIUS__

DIMENSIONS & CLEARANCES

INBOARD (DE)		OUTBOARD (ODE)	
I.D. BRG	____________________	I.D. BRG	________________
JOURNAL DIA	____________________	JOURNAL DIA	________________
CLEARANCE	____________________	CLEARANCE	________________
I.D. BRG HSG	____________________	I.D. BRG HSG	________________
O.D. BRG	____________________	O.D. BRG	________________
FIT + OR –	____________________	FIT +OR -	________________
HOUSING/CARTRIDGE FIT +OR-		FIT +OR -	________________

I.D. SEAL	#1___________	#2____________	#3____________	#4______________
SHAFT SEAL AREA	#1___________	#2____________	#3____________	#4______________
CLEARANCE	#1___________	#2____________	#3____________	#4______________

OUTPUT SHAFTS

POSITION ON SHAFT – FLUSH, PAST FLUSH, FROM FLUSH	_____________	POSITION ON SHAFT – FLUSH, PAST FLUSH, FROM FLUSH	______________
(POSITION "A') DIA.	_____________	(POSITION "K") DIA	______________
COUPLING I.D.	_____________	COUPLING I.D.	______________
INTERFERENCE	_____________	INTERFERENCE	______________

Appendix C **(CONT.)**

OTHER OR SPECIAL ATTENTION TO: ____

INSPECTED BY: ______________________________________ DATE__________________

DC MOTOR STRIP REPORT

SERVICE
SHOP: ___________________ CUSTOMER: _________________________ JOB NO.:______________ DATE_________

MOTOR DATA

MFGR: __________________________ HP: ___________________ SERIAL NO. ______________________
RPM: _________________________ TYPE: __________________ Equipment name: _____________________

FIELD POLE WINDINGS

CONDITION/PROBLEMS FOUND:	
CORRECTIVE ACTIONS PROPOSED:	

MATERIAL COST: $___________________ LABOR COST: $________________

ARMATURE & SHAFT

CONDITION/PROBLEMS FOUND:
CORRECTIVE ACTIONS PROPOSED:

MATERIAL COST: $_____________________ LABOR COST: $______________________

DC MOTOR FRAME, BEARING BRACKETS, BEARINGS, SEALS, MISC.

CONDITION/PROBLEMS FOUND:
CORRECTIVE ACTIONS PROPOSED:

MATERIAL COST: $_____________________ LABOR COST: $______________________

WORK TO BE SUBCONTRACTED:

VENDOR: _________________________
DESCRIPTION OF WORK:

____

COST: $________________________

VENDOR: _________________________
DESCRIPTION OF WORK:

____

COST: $________________________

SERVICE SHOP SIGNATURE: ___________________________ DATE: _________________________

DC MOTOR DATA STRIP REPORT

JOB# ____________________

ELECTRICAL / MECHANICAL

NAME DATE PHONE

COMMENTS:

OWNER SIGNATURE: ________________________________

OTHER

NAME DATE PHONE

COMMENTS:

OTHER SIGNATURE: ________________________________

COST OF LABOR: $ ____________________

COST OF MATERIAL: $ ____________________

COST OF LABOR FOR ADDITIONAL REPAIR: $ ____________________

COST OF MATERIAL FOR ADDITIONAL REPAIR: $ ____________________

COST OF SUBCONTRACTED REPAIR: $ ____________________

COST OF SHIPPING: $ ____________________

TOTAL COST: $ ____________________

DATE OF RETURN DELIVERY: ___________________________

REPAIR AUTHORIZATION:

OWNER: ____

NAME DATE PHONE

DEPARTMENT/PURCHASING SIGNATURE: __________________________

Appendix E DC MOTOR REPAIR REPORT FORM

Customer ______________________________ Job# _________________________________

Motor ID/Tag Number ___________________ Date ______________ Vertical___________

Serial Number ___________________________ Application________ Horiz. ____________

MOTOR NAMEPLATE DATA

Horse Power	Armature	RPM	Armature Amps
/	/	/	
Shunt Field Amps	Shunt Field Volts	Shunt Field Ohms	Service Factor
/	/		
Temperature Rise	Ambient Temperature	Form/Random Wound	Manufacturer
Insulation Class	Enclosure	Type	Model
Bearing size PE/OPE	PE Bearing*	OPE Bearing*	
/			

*S=Sealed; H=Shielded; O=Open

Work Performed: Circle the appropriate items below or fill in as necessary.

ARMATURE:	Rewind	Clean	Clean & Paint	VPI/Dip & Bake	
SHUNT FIELD:	Yes	No			

ARMATURE AND /OR FIELD POLES SHORTED IRON: YES NO

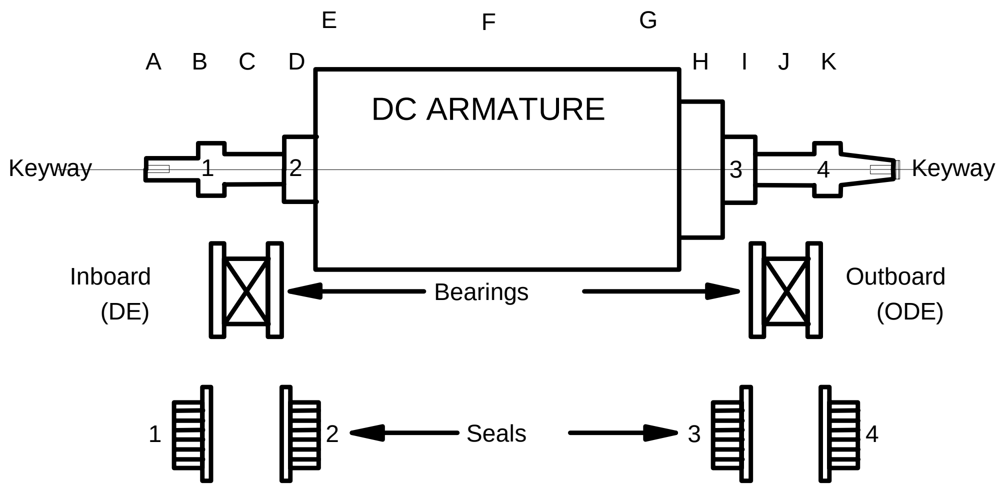
If YES, action taken:____

MOTOR LEADS:	Repair	Replace	Seal	OK	
BRUSH HOLDERS:	Reinsulate	Repair	Replace	Clean	
BRUSHES:	Replace	N/A			
COMMUTATOR:	Repair	Rebuild	Replace	Turn	Undercut
MECHANICAL:	Repair	Replace	Other: ________________		
A. HOUSING	Repair	Replace	Other:________________		
B. SHAFT	Repair	Replace	Other:________________		
SLEEVE BEARINGS:	Rebuild	Replace	Scrape	Reinsulate	N/A
ANTIFRICTION BEARINGS:	Replace	N/A			
BEARING SEAL:	Rebuild	Replace	Remachine	Reset	N/A
BLOWER:	Rebuild	Replace	Remachine	Repair	
HEATER:	Rebuild	Replace	Repair		
COUPLING:	Rebuild	Replace	Remachine	Reset	

MECHANICAL INSPECTION FOR DC MOTORS AS COMPLETED

RUN OUT POSITIONS

CUSTOMER ___________________



Job # ______________

MFR. ______________

RPM ________ HP ____

SERIAL # ____________

DIAMETERS & TOTAL INDICATED RUNOUTS

DIAGRAM POSITION

		DIA.	TIR.
OUTPUT	A	________	______
OUTER SEAL AREA	B	________	______
BEARING FIT	C	________	______
INNER SEAL AREA	D	________	______
ARMATURE BODY	E	________	______
ARMATURE BODY	F	________	______
ARMATURE BODY	G	________	______
COMMUTATOR	H	________	______
INNER SEAL AREA	I	________	______
AUX OUTPUT	K	________	______
BEARING FIT	J	________	______

KEYWAY DIMENSIONS

"A" OUTPUT: L_____W _____ D _____ Radius_______

"K" OUTPUT: L_____W _____ D _____ Radius _______

DIMENSIONS & CLEARANCES

INBOARD (DE)		OUTBOARD (ODE)	
I.D. BRG	________________	I.D. BRG	________________
JOURNAL DIA	________________	JOURNAL DIA	________________
CLEARANCE	________________	CLEARANCE	________________
I.D. BRG HSG	________________	I.D. BRG HSG	________________
O.D. BRG	________________	O.D. BRG	________________
FIT + OR –	________________	FIT +OR -	________________
HOUSING/CARTRIDGE FIT +OR-	________________	HSG/CART FIT +OR -	________________

I.D. SEAL	#1________	#2________	#3________	#4________
SHAFT SEAL AREA	#1________	#2________	#3________	#4________
CLEARANCE	#1________	#2________	#3________	#4________

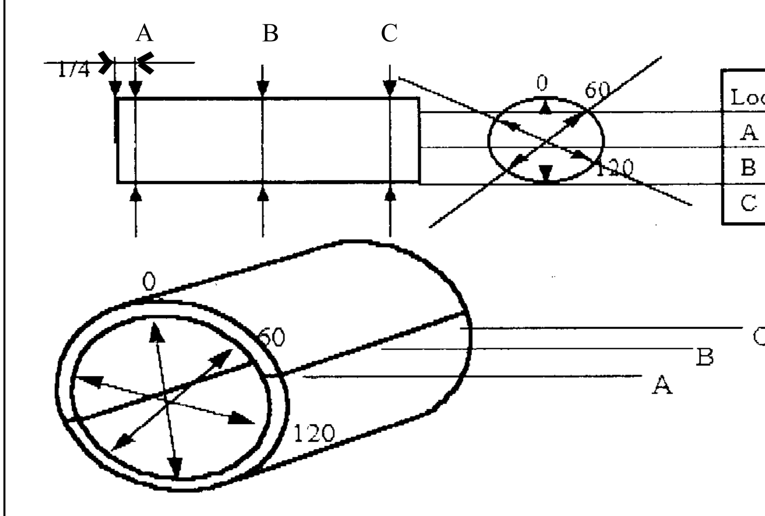
OUTPUT SHAFTS

POSITION ON SHAFT – FLUSH, PAST FLUSH, FROM FLUSH	__________	POSITION ON SHAFT – FLUSH, PAST FLUSH, FROM FLUSH	__________
(POSITION "A") DIA.	__________	(POSITION "K") DIA	__________
COUPLING I.D.	__________	COUPLING I.D.	__________
INTERFERENCE	__________	INTERFERENCE	__________

OTHER OR SPECIAL ATTENTION ITEMS:

INSPECTED BY: ______________________________ DATE______________________

SLEEVE BEARING DIMENSIONS

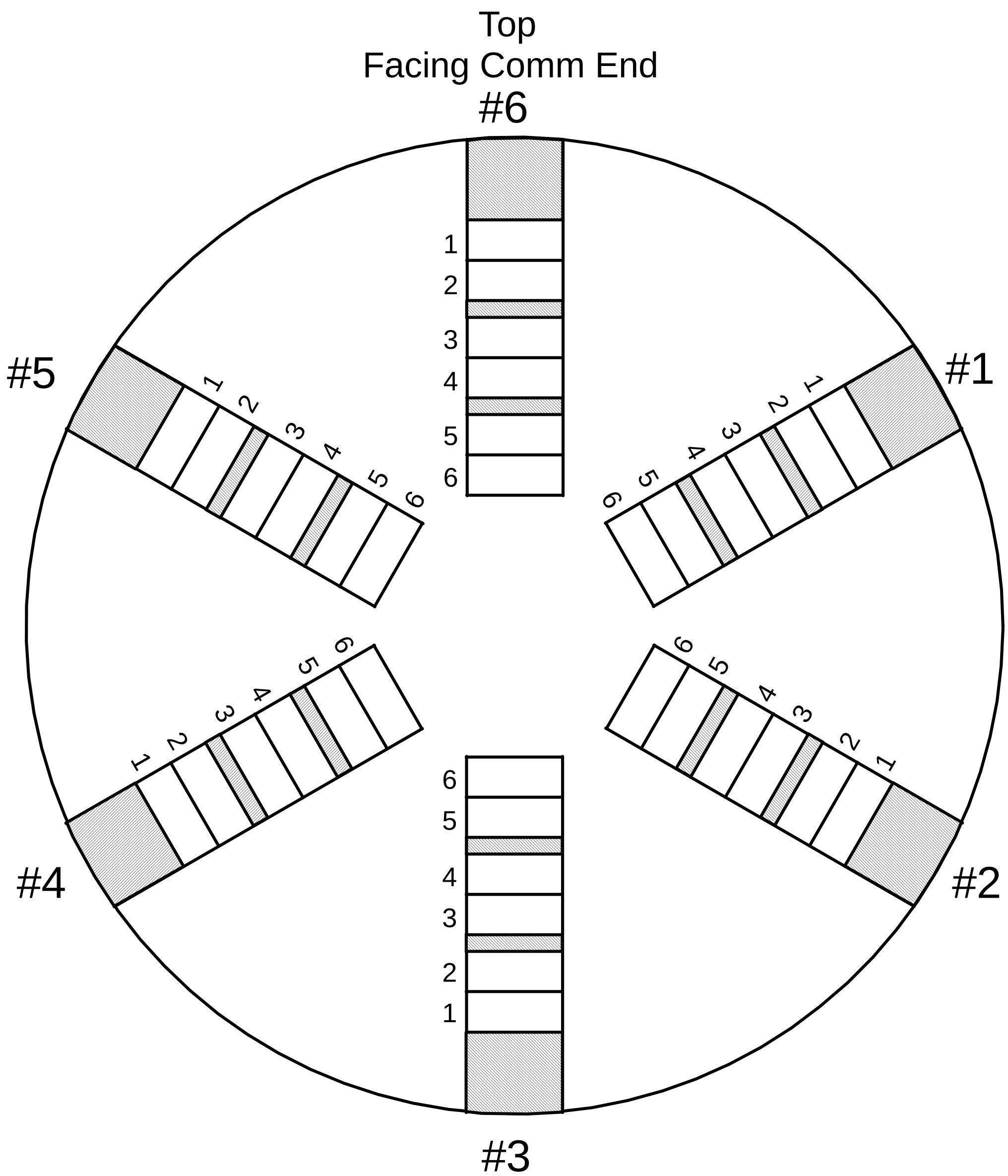


Loc	0	60	120
A			
B			
C			

Loc	0	60	120
A			
B			
C			

APPENDIX G

DC MOTORS
BRUSH SPRING TENSION
IN POUNDS



Brush Boxes are Reading #1 thru #6 with #1 Nearest to the Brush Yoke

Brush Manuf. ________________

Brush No. ________________

Brush Size: L ______ W ______ D ______

Appendix H DC MOTORS

DYNAMIC BALANCING CERTIFICATE

Vendor: ______________________________ Balance Date: ________Time:____

Motor Tag #: _________________________ Vendor No.: _____________

Equipment balanced: ____

Balance Machine Model No.: _____________, Last Calibration Date: ________

Balance Machine Serial No.: _________________________

Armature Weight: ___________, Armature "In Service" Speed: (RPM) ________

Balance Speed: (RPM) _________________________

Radius of permanent balance weight: (in.) __________IB, ______________OB.

As Found Balance: (oz. in.) ____________________IB, __________________OB.

As Left Balance: (oz. in.) _____________________IB, __________________OB.

Calculated acceptance limit per journal (4W/N): __________IB, _________OB.

If oz. in. value is not available for "As Found Balance" and "As Left Balance" use the mils value.