AC MOTORS REPAIR SPECIFICATION

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DATED: 3/1/99 Revision 8/16/05

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 AC MOTORS REPAIR SPECIFICATION

Revised: 8/16/05

1.0 – Overview

1.1 – Mission

This recommended practice covers general recommendations for the repair of AC 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 horizontal and vertical motors, NEMA frame size 140 and above, having a voltage rating of 15 kV or less. These recommendations apply only to the repair of motors 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 listed explosionproof and dust-ignitionproof 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 Modifications: Include conversions 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 an alternator.

2.3 – Repairs: Include 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 or subcontractors 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 to be of high quality and cost effective, the User should prepare in advance 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 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 are to be stored by the User and Repair Facility 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 "F" or "H" 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, and
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 Facility 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, "top" and "bottom" for vertical shaft units.

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 Appendixes B, D, and E as applicable.

6.1 – Incoming Tests

Prior to an incoming run test, perform the following and record information where appropriate:

A. Motor must be mechanically inspected to determine if shaft turns freely.

B. Verify that bearings are lubricated.

C. Insulation resistance tests should be performed. (See Section 8.1, I through L for minimum insulation resistance values, temperature compensation requirements, and test voltages.) See Appendixes A and E for a motor data insulation resistance record form.

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

1. Continuity of stator windings
2. Condition and installation of brushes, if applicable
3. Single-phase, low-voltage test (approximately 10-20% of rated voltage) on AC squirrel-cage rotor to find defective rotor bars—maximum accepted line current variation <3%, as the shaft is rotated with full-load current applied per IEEE Std. 1068-1996
4. Polarization index (where appropriate)
5. Surge test (where appropriate)

E. If conditions permit, the motor should be run at reduced voltage initially (25 - 50% of rated voltage). If the test is successful, complete the data sheets in Appendixes A and C, and then run the motor at full voltage, if possible.

F. 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 Received" 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 sheet in Appendix A.

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 rotor 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 connection).

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 other information is not available, use the following:

AC motor runout =
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 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

Inspect condition of bar joints, end rings, windings, slip rings, key ways, threaded fits, synchronous pole pieces, etc. (Note: Complete Appendixes B and C.).

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) Collector ring diameter
6) Brush size and type of quantity

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 stator laminations, mounting blocks, welds, machined fits, brush rigging, space heaters, etc.

G. Visually inspect rotor pole pieces, mounting blocks, amortisseur windings, leads, etc.

H. When inspecting squirrel-cage rotor bars and their connecting end rings inspect for cracks, arcing in slots, and for cage migration. All cracks and evidence of arcing should be recorded and, if possible, pictures should be taken showing the location of damaged bars or end rings. 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.

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 (Appendix D).

8.0 – Repair Procedures

8.1 – Electrical

Stator Windings. Observe the following:

A. Slot wedges ("top sticks") 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. Windings of motors rated 5 kV and above that have slot partial discharges will have evidence white or gray powder on the surface.

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 all coils appear equally overheated, likely causes are ventilation failure, under-voltage, stalling, or prolonged overload. If coils within one phase are largely undamaged, the likely causes are single-phase operation or serious voltage unbalance. If only certain coils adjacent to line 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 no stator winding damage is apparent, test the insulation resistance for windings using a megohmmeter in accordance with IEEE Std 43-2000. Record the value of insulation resistance (IR) between the winding (all leads connected together) and the stator core. Test voltage, applied for one minute, should be as follows:

Rated motor voltage	Megohmmeter test voltage, DC
240/480	500
2400	1000
3000 – 4800	2500
5200 – 13800	2500 or 5000

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 thermometer.

K. To correct IR readings to the reference temperature, use the formula found in IEEE's 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.

L. Windings in apparently good condition should receive a DC Overpotential Test (HIPOT) for one minute at a voltage *T* calculated as follows:
(Record microamps on Appendix B.) (HIPOT to be requested by User.)

$$T = 0.65\,(2E_m + 1000\text{ V})(1.7)\text{ Volts}$$

480V = 2166 VDC
2400 V = 6409 VDC

Where E_m = Rated motor nameplate voltage

M. 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.

N. Inspect the stator core structure itself carefully for evidence of severe corrosion, core shifting, local overheating of laminations, loose or broken slot teeth, loose or broken finger plates, core blocking, loose or shifted vent spacers, or rub marks from contact by the rotor or material caught in the air gap. A Core Loss Test should be performed to evaluate the condition of the laminations.

O. The rotor is the second major electrical component to be appraised. Cleanliness, laminations, vent spacers, slot tooth condition, and rub marks are checked as in the stator. Rotor laminations should be checked for "coning" (separation of laminations, causing the length of the rotor to be greater at the outer diameter than it is at the shaft).

P. A squirrel-cage rotor will be the type most often encountered. It may use a cage-bar and end ring structure that is cast in place using aluminum alloy, a fabricated aluminum bar and ring assembly, or a fabricated copper alloy cage. Whichever the type, using a dental mirror if necessary, inspect all accessible surfaces of bars and end rings, looking for "blued" (overheated) areas, cracks, missing pieces, bar movement in the slots, porous or deteriorated brazed or welded joints, and bars that have "lifted" outwards in the slots under centrifugal force. If rotor bar/and ring irregularities are suspected, the fabric banding hiding the bar to end ring joints should be removed for inspection if needed. Record the location and nature of all defects found.

Q. When overheated or melted bars are present, the most severe damage will typically be at the ends of the rotor, outside the core stack, when starting duty is the source of trouble. If running overload or blocked ventilation is the problem, rotor damage is more likely to be within the core stack itself.

R. Look for evidence of arcing or burning along the edges of bars adjacent to slots. This generally indicates bar looseness.

S. One or more cracked or broken cage bars normally dictate replacement of the entire cage. If the rotor cage requires replacement, aluminum or aluminum alloy cages should be of low copper content (0.2% or less). Copper or copper alloy cages should use metal joining material that is phosphorus free. If bars are loose but undamaged, swaging (with a properly radiused tool) of the bars near each end of the core stack and at one or more locations along the stack length may expand the bar material sufficiently to tighten the fit. Swaging is not acceptable if the bars are of the T-shape (narrow top, wide bottom) designed for a loose fit of the upper portion. Varnish treatment of a rotor containing a loose cage, even if vacuum-pressure impregnation is used, will not permanently lock loose bars in position and shall not be used to repair a loose cage. Unless the bars can be mechanically tightened, they should be replaced.

T. The entire rotor should be tested in one of two ways to locate broken cage bars that are not otherwise apparent. If the stator and bearings are in usable condition, a single-phase test may be performed (Applying typically 10% rated voltage to only two leads of the stator winding, turn the rotor slowly by hand and observe for current variations indicating the possible presence of cage defects; see 6.1.D.3.). Otherwise, the removed rotor can be similarly tested on a "growler". Neither test, unfortunately, is either infallible or procedurally standardized. A typical difficulty is that the halves of a broken bar may separate only when the rotor is hot, the gap closing again when the rotor cools off. Oven-heating the rotor for a short time prior to a Growler Test may be helpful.

U. Examine steel retention caps or "shrink rings" (usually attached to the ends of high-speed rotor cages to restrain centrifugal expansion) for signs of distortion, looseness, or fretting. End rings themselves in such rotors may sometimes fail by being expanded outward into a somewhat conical shape by high centrifugal forces—a condition that must be corrected by replacement rather than remachining.

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, 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 50 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 Par. 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 as noted on Appendix B (except if advised differently by User).

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

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

8.2.1 – Recondition of Stator

A. All components' parts shall be thoroughly cleaned. Steam cleaning is the preferred method. 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 110°F to 130°F to remove air and moisture and ensure thorough impregnation. Oven temperature must not exceed 290°F during the drying cycle for Class "F" or "H" insulation. Oven temperature must not exceed 250°F for Class "A" or "B" insulation.

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

D. The stator must be sealed. If the stator is well sealed, no additional varnish is required. If the stator requires sealing, the "Dip and Bake" method is recommended. If this is not practical, either the spray or flow method 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 AC motors.

8.3 – Stripping and Cleaning

One of the most potentially damaging procedures in the rewinding operation is the removal of the old, failed, electrical windings. The controlled oven burnout is the recommended practice.

8.3.1 – Oven Burnout

Prior to burnout, a Core Loss Test is to be performed by the Repair Facility. Coils are to be removed after burned out in the burnout oven. Monitor and record the stator laminations with a recording temperature indicator. Temperature recordings are to be available to User, inspector, or authorized representative. A copy of this time/temperature recording is to be submitted with data sheets. Control the oven chamber to 650°F (353°C) or below and stator laminations to a maximum of 725°F (385°C) to prevent damage to the lamination insulation. Control the rate of temperature rise to prevent ignition of combustibles.

Note: The use of hand-held torches or direct flame is not acceptable.

8.4 – Replacement of Coils and Insulation System

A. After removal of the old coils, but prior to replacement of the coils, a Core Loss Test is performed, if acceptable, and the laminations should be cleaned, inspected, repaired if necessary, and repainted.

B. Slot liners are recommended for all motors.

C. 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.

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

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

F. RTDs or thermocouples should be placed within the windings if they were part of the original design or requested to be added by the User. Special care should be taken to ensure that the proper type RTD is used, and that the temperature/resistance values are in calibration. Record RTD type on Appendix B.

G. Insulation

Insulation systems shall be classified as follows:

- *NEMA Class A.* 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 A temperature specified in the temperature rise standard for the machine under consideration.
- *NEMA Class B.* 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 B temperature specified in the temperature rise standard for the machine under consideration.
- *NEMA Class F.* 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 F 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 H temperature specified in the temperature rise standard for the machine under consideration.

1. Only class "F" or "H" or better insulating materials will be used for the following components:
   a. Slot insulation
   b. Magnet wire (Heavy armored P. Thermalex~~e~~ 200~~0~~ or GP 200)
   c. Phase insulation
   d. Wedges/middle wedges
   e. Sleeving (Acryliglass)
   f. Tie cord
   g. Varnish
2. Phase insulation will be used on all coil and turns over 5 HP. A separator will be provided between each coil in slots.
3. Motors name-plated Class "H" insulation will be rewound Class "H" in all respects.
4. All components that constitute the insulation system will be compatible with each other.

H. Construction of Coils through 6600 Volts

1. The 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 assembling in the stator. 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.

2. The coils are to be wound, connected and insulated in the unimpregnated state unless the VPI vessel size prohibits post-impregnation of the completely wound stator. All connections between coils, phase rings, and leads are to be silver soldered or brazed and completely sealed with ground wall insulation of layers of tape.

3. Lacings and ties are to be thermosetting synthetic-resin impregnated glass-fiber roping and tapes. All coils are to be securely tied to the surge rings and adjacent coils. Conforming material shall be provided between the surge ring and the bottom coil side and top coil sides. All blocking must be tied.

I. Provide corona suppression treatment on the outside of the coils for equipment nameplate rated at or above 6600 volts. HIPOT any area that has corona suppression treatment.

1. Provide at least one sacrificial coil, oriented in the stator in line with the stator coils, installed in a facsimile slot, which undergoes the complete VPI process (including cure) with the stator.

2. Stators too large for VPI as a complete unit shall be constructed with windings that have been VPI'd with a 100% solids, synthetic thermosetting resin. The entire stator shall be heat treated to cure all resins. Use VPI process at the discretion of the User.

3. Clean the ventilation and air passage so that they are free and clear of restrictions before assembly.

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

8.4.1 – Inspection and Removal of Field Coils for Synchronous Rotors

A. Prior to disconnecting the wiring, make an accurate drawing showing the location of all poles, wiring, fan blades, and associated hardware. Shaft keyway can be used as a reference indicating relationship of collector rings, brush exciter, leads, and wiring cleats.

B. Each pole piece should be match marked with respect to the rotor spider 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 collector ring or exciter end.

C. Measure and record the axial location of the pole pieces with respect to the rotor core and shaft. (Generally, this is best accomplished by identifying Pole #1, placing a center punch mark at its mid-point, and measuring the distance from the center punch mark to the shaft reference. Then using this dimension and shaft reference, place a center punch mark on each of the remaining poles. Locating the poles in this manner will allow the rotor to be returned to its correct magnetic center. An alternate method is to measure the distance between each pole piece dovetail and its outside rotor slot edge.)

D. When inspecting collector rings, if the rings must be removed in order to dismantle the poles, all orientations for the rings should be recorded on a drawing.

E. Squirrel-cage rotor bars and their connecting end rings should be inspected for cracks, arcing in slots, and for cage migration. 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.

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 scrapping" as in the following:

1. Bearing and journals must be mic'd and compared to the manufacturer's tolerances. Both the bearing and journal are to be mic'd at three locations across the length; the location for these readings is 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 Appendixes F and F-1.

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 1-2 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 rotor 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 rotor weight resting on it.

3. If the bearing halves are not within limits, according to the manufacturer's specifications, both bearing halves must be rebabbitted 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 a 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 dissymmetries. The integrity of this insulation, as applied to the bearings themselves, should be tested during the reassembly process. (See paragraph 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 endplay in accordance with the machine's design limits. For horizontal shaft antifriction bearing motors, the endplay 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 rotor positions—such that the rotating assembly will "float" at its magnetic center position within the normal endplay limits. This natural rest position will be indicated by 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 and repair all leaks as needed.

8.6 – Rotor/Stator

8.6.1 – Stator and Rotor Lamination Repair

A. Eliminate laminations with mechanical or electrical damage. The following four methods of repairing laminations in a motor stator or rotor 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.

1. *Method One*. (Stator is slightly rubbed by the rotor, 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. 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 reinsulate the fingers. This method assumes the damage is near the end of the stator 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 rotor.) 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 stator or rotor 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 rekeying the lamination in the frame.

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

B. Rotor/shaft assemblies should be lifted and handled carefully so as not to transmit any lifting or other stresses to any part of the rotor 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 rotor to drag against the inner diameter of the stator when inserting the rotor into the stator.

C. Centering of the rotor within the stator should 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 rotor 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 rotor is turned in 60° steps, noting the reading at each step. This test can reveal an eccentric rotor 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

9.0 – Balancing

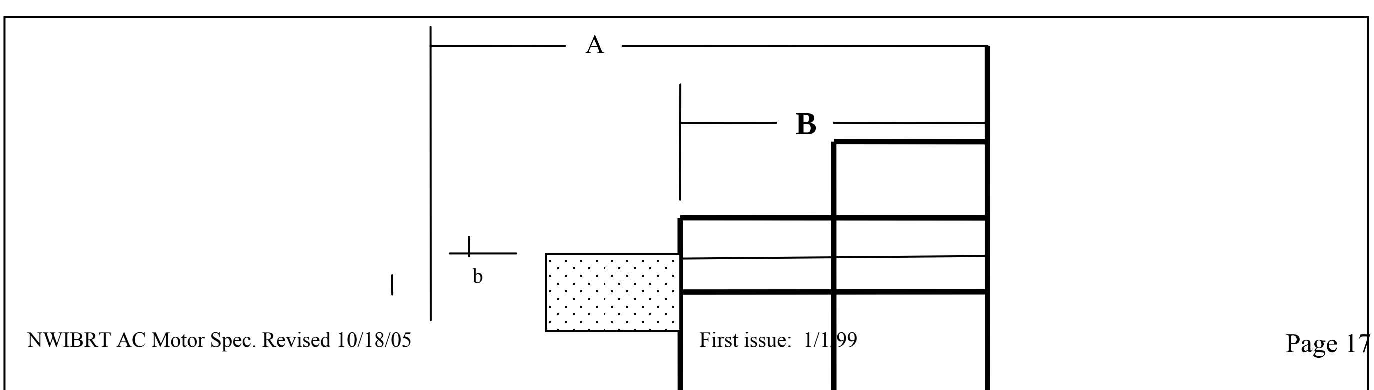
9.1.1 – Balancing – Shaft and Fitment Key Convention

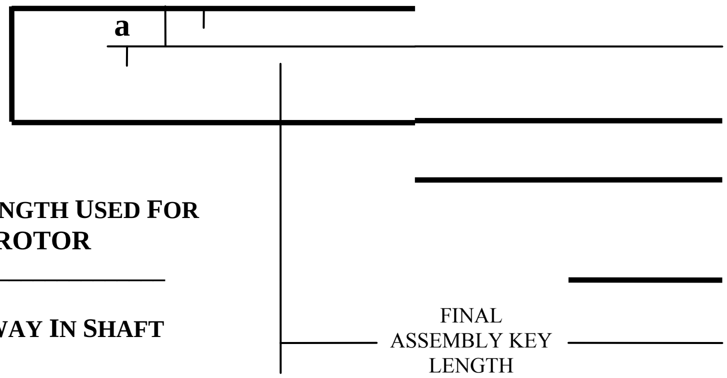
9.1.1.1 – Standard Key

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 rotors 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 as 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 ROTOR

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 = __________________

ROTOR 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 name plate 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 rotor 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 rotor.
- The attachments of weights to the rotor shall be done using non-corrosive material and good practices to insure the integrity of the rotor and the attachment.
- It is recommended that old weights be removed rather than applying new weights to oppose them.

C. Balance Methodology

- Rotors shall be supported in the balancing machine on the bearing fits, if practical. If not practical, it is acceptable to support the rotor 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 rotors and rotors with integral attachments will initially be balanced in at least two planes without external attachments installed to the shaft.
- If the rotor is to be fitted with external attachments or fixtures (coupling hubs, brake wheels, etc.) when delivered to the customer, it is recommended that these external attachments be fitted to the already balanced rotor using a standard key as described in this document. The rotor 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 rotors, rotors with integral attachments, and rotor 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.

$$U_{per} = (4 \times W)/N$$

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 vendor 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. The result of this balance standard calculation is similar to an ISO 1940/41 G 0.67 specification.

E. Balance Report

- A copy of the report from the final run of the rotor or rotor with integral attachments as well as a copy of the report from the final run of the rotor assembly will be supplied to the User. At a mimimum, the reports should identify the rotor, motor, and job, indicate the date and time of the run, rotor weight on each journal, in service speed of the rotor, 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 G.

10.0 – Electrical Connection

A. 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
5/16	21
3/8	38
1/2	85
5/8	175

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.

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 stator 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

All assembly will be according to good machine shop practices.

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 material.

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

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

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.

All assembled components will be checked to ensure secure fits.

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

Motor terminals must be identified outside the motor frames.

New brushes will be installed on all motors.

A. Replacement brushes will be made in kind.
B. Vendor will supply all brushes.
C. Brushes will be properly seated to ensure proper commutation. Brush holders will be reconditioned or replaced as required.
D. Brush pressure springs will be checked and recorded in Lb./sq. in. to ensure equal loading on all brushes.

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

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

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

A repair ID Tag will be added showing shop name, identification number and date of repair.

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

Run test shall be a minimum of 45 minutes duration at the rated voltage and 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 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.

On squirrel-cage motors, check the current on all connections and check speed of the motor. The current on each phase should be within 10% deviation between any two other phases.

On wound rotor motors, apply full primary voltage to stator and with rotor circuit open for a non-rotational test. Measure rotor open circuit voltage and stator current.

A non-load test run will be made on all motors to ensure that all electrical readings do not exceed the Name Plate Data ratings.

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. "As Found" tests will be conducted during the full voltage, full speed, and no load run test of a motor sent for repair prior to disassembly. If a full voltage test is not performed, these "As Found" vibration tests will be performed at reduced voltage while at full speed.

B. 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.

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

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

13.4 – Acceptance Tests

A. "Acceptance" tests will be conducted after the machine is assembled. They will be performed at full voltage, at full speed, under no load, and after the machine has achieved thermal stability. In the case of high voltage motors, "Acceptance" tests may be performed at reduced voltage, at near full speed (within 6% of synchronous speed), under no load, and after the machined has achieved thermal stability with the written approval of the User.

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.

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 calibrated instrumentation that is in good condition to insure accurate, reliable results and shall be performed by ISO 18436-2 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 18436-2 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 Facility 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 User will maintain measurement results of all vibration tests in electronic (preferred) or hardcopy form for a minimum of 10 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 below, will be conveyed to the customer 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 tests 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,
   3. A tabular representation of the maximum band limited overall amplitude in G's peak for each frequency band and location,
   4. A tabular representation of the maximum allowable vibration limits for both 3 and 4.

J. 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, 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 72 dB 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 four (4) linear averages with no more than 50% overlap processing is required. No more than 16 averages will be used for any measurement.

7. If overlap processing is available in the instrument, no more than 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 500mV/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 2000Hz.

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.

F. 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 six 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 & MTR IB HOR or
   MTR ODE HOR & 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 & MTR IB VER or
   MTR ODE VER & 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 position. These will be described using the conventions
   MTR OB AXL & MTR IB AXL or
   MTR ODE AXL & 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 six 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 & MTR IB INL or
   MTR ODE INL & 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 & MTR IB PER or
   MTR ODE PER & 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 & MTR IB AXL or
   MTR ODE AXL & 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

A. Acceptable Units

1. Frequency	Hertz or CPM
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 five (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

A. 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; 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 10% or four (4) inches, whichever is the greater.
   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 six (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 Sync Speed	Minimum Deflection
720	1.56″
900	1.00″
1200	0.56″
1800	0.25″
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

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. 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, finish paint can be chosen by the Repair Facility. 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. Final Inspection and Shipping Preparations

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

16. Shipping Precautions

A. For either railcar or highway truck transportation, rotor/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. Field Repairs

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 AC MOTOR INCOMING CHECK LIST

CUSTOMER __________________ JOB # .______________________

DATE ______________________

EMPLOYEE NO.______

1. MEGGER TEST. STATOR - VOLTAGE_______________ RESULTS____________________MEGS.

WOUND ROTOR/SYN. - VOLTAGE_______________ RESULTS____________________MEGS.

2. SPIN SHAFT AND CHECK TIR RUNOUT (RECORD).____________________

3. PUT REDUCED VOLTAGE SINGLE PHASE ON MOTOR-25% OF RATED,
TO CHECK FOR A DEFLECTION IN THE METER FOR OPEN ROTOR BARS.

4. IF ABOVE TESTS OKAY, RUN MOTOR NO-LOAD AND RECORD DATA.

VOLTAGE______________ RPM____________ CURRENT___________
BRG.TEMP__________DE_______ODE

5. ON SLIP RING ROTORS, CHECK SECONDARY VOLTAGE AND RECORD______________________

6. RECORD AND REMOVE COUPLING, IF NEEDED.

7. DISASSEMBLE MOTOR.

8. IF IT HAS HEATERS, RECORD VOLTAGE AND WATTS, AND DRAW WIRING DIAGRAM.

9. CHECK ALL BEARING SIZES, FITS, AND RECORD ALL NUMBERS ON JOB SHEET.

10. RECORD ALL BROKEN BOLTS, T-BOXES, EYE BOLTS, AND ANY OTHER VISUAL PROBLEMS THAT ARE SEEN ON THE MOTOR.
11. RECORD ALL SPACERS, SNAP-RINGS, AND SEALS WHERE THEY BELONG.
12. IF MEGGERS TO SPECIFICATION, PROCEED WITH SURGE OR PHASE BALANCE AT 25% OF RATED VOLTAGE.

RESULTS:____(SURGE/PHASE VOLTAGE)___________AC

13. PUT ALUMINUM TAGS ON LEADS BEFORE STEAM/BAKE.
14. NOTE ON JOB SHEET IF THE WINDINGS ARE FLARED, LENGTH OF COIL EXTENSIONS, LEAD-NUMBERS, AND IF THERE ARE INTERNAL AIR SHIELDS, AND FANS.
15. STAMP JOB NUMBER BY NAME PLATE OR ON A FLAT SPOT BY THE EYE BOLT. FOR THE ROTOR, STAMP NUMBER ON END OF SHAFT (ODE END).
16. CHECK AND RECORD ALL RTD'S, RESISTANCES, AND HEATERS.

____

____

NOTES:____

SUPERVISOR____DATE________________

Appendix B **AC MOTOR DATA SUMMARY**

Customer ________________________________ Job# ______________________

Motor ID Tag # ______________________________ Date received _________________

Serial Number _______________________________ Shop ID number _______________

Temperature _______________ Humidity _______________

Surge test _________________ passed _____________ failed ____________

	Before	After
Voltage		
Megohms		
Microamps		
Tester Init.		

Bearings *Indicate: S=sealed, H=Shielded, O=Open

	Drive-end bearing		Opposite drive-end bearing	
	Found	Left	Found	Left
Bearing size				
Shaft size				
Mfgr.				
Type*				
Model #				
# Balls/Rollers				
Tester Init.				

Rotor Air Gap

	Before		After	
	Opp. Drive end	Drive end	Opp. Drive end	Drive end
Vertical 0°/180°	/	/	/	/
60°/240°	/	/	/	/
120°/300°	/	/	/	/
# Rotor Bars				
# Stator Slots				
Tester Init.				

Heater Voltage _______ Wattage ______ RTD type _____________

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

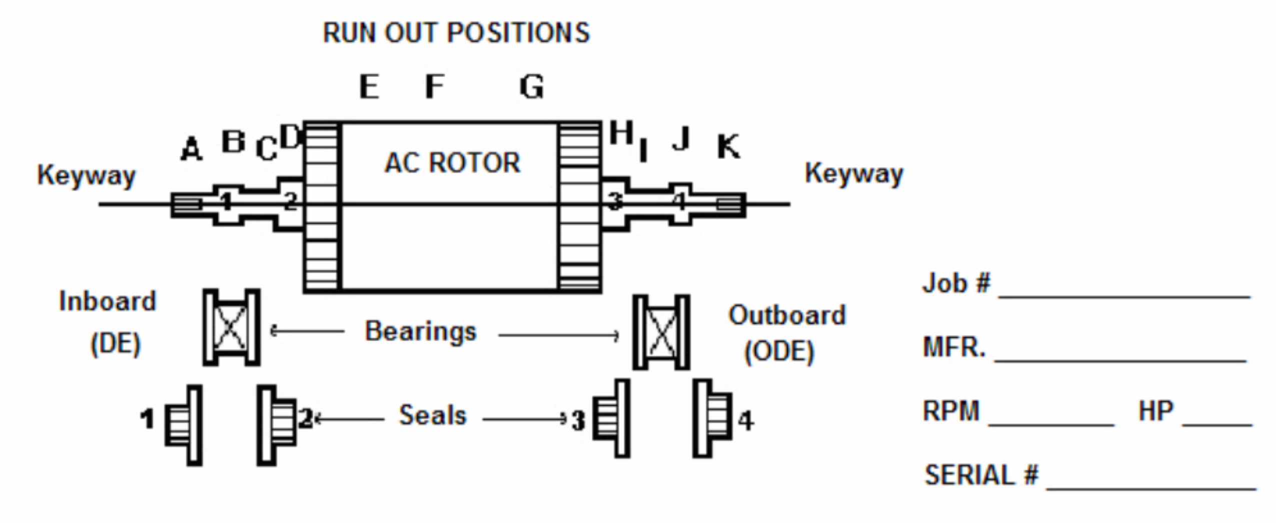
Appendix B-1 AC MOTORS

FAILURE ANALYSIS CAUSES

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

MECHANICAL INSPECTION FOR MOTORS AS RECEIVED

CUSTOMER ____________



TOTAL INDICATED RUNOUTS

DIAGRAM POSITION

OUTPUT A________
OUTER SEAL AREA B________
BEARING FIT C________
INNER SEAL AREA D________
ROTOR BODY E________
ROTOR BODY F________
ROTOR BODY G________
INNER SEAL AREA H________
WDTH________DEPTH________LENGTH_______
BEARING FIT I________
WIDTH_________DEPTH________LENGTH_______
OUTER SEAL AREA J________
AUX. OUTPUT K_______

VISUAL CONDITION OF SHAFT, BEARINGS & SEALS

COLLECTOR RINGS	BRUSH SIZE
Collector ring	Brush
Diameter________________	Mfg.______________

KEYWAY DIMENSIONS

"A" OUTPUT

"K" OUTPUT

INSTRUMENT

DIMENSIONS & CLEARANCES

INBOARD (PE)			OUTBOARD (OPE)	
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	__________

OTHER OR SPECIAL ATTENTION TO: ____

____

____

INSPECTED BY ______________________________ DATE______________

Appendix D **AC MOTOR STRIP REPORT**

SERVICE
SHOP ____________________ CUSTOMER __________________________ JOB NO.______________ DATE__________

MOTOR DATA
MFGR ___________________________ HP ____________________ SERIAL NO. _______________________
RPM __________________________ FRAME ___________________ Equipment name ______________________

STATOR WINDING
CONDITION/PROBLEMS FOUND ____

CORRECTIVE ACTIONS PROPOSED ____

MATERIAL COST $____________________ LABOR COST $_________________

ROTOR AND SHAFT
CONDITION/PROBLEMS FOUND

CORRECTIVE ACTIONS PROPOSED

MATERIAL COST $______________________ LABOR COST $_______________________

STATOR 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 __________________________

AC 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 AC MOTOR REPAIR REPORT FORM

Customer ____________________________ Job# ________________________________

Motor ID/Tag Number __________________ Date _____________ Vertical__________

Serial Number _________________________ Application________ Horiz. ___________

MFG	hp/kW	Voltage	Amps	Phase	Hz	RPM	Enclosure

Frame	Insulation class	Form/random wound	Model

Type	Style	Design	Code	Service factor

Power Factor	Exciter A	Exciter V	Secondary A Secondary V	Temperature rise		Ambient temperature	

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

STATOR:	Rewind	Retreat	Clean and Paint	
STATOR SHORTED IRON:	Yes	No		
SURGE TEST	Yes	No		

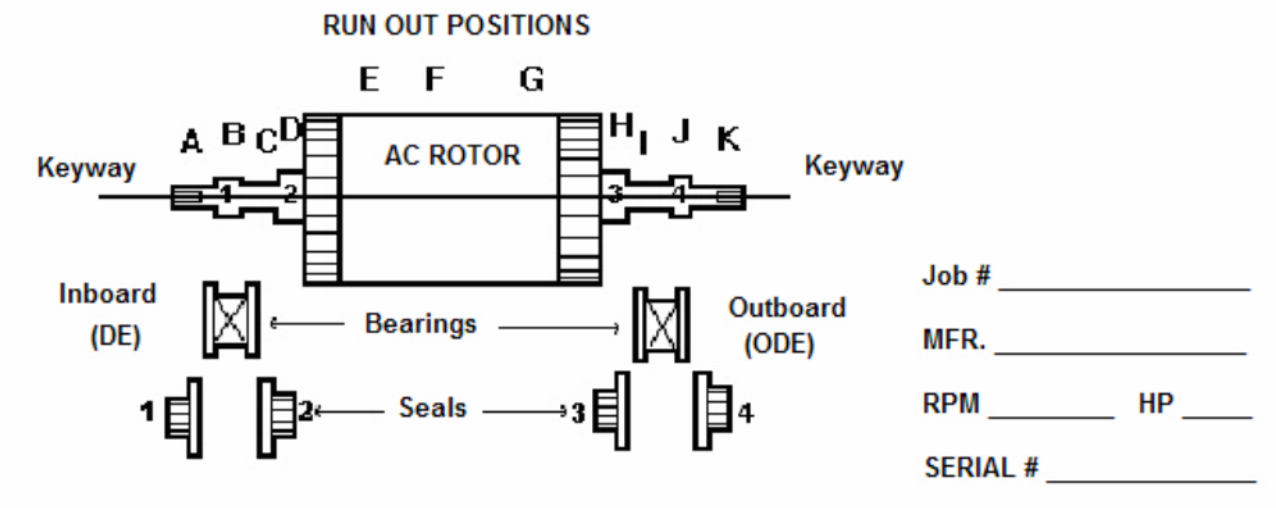
If found shorted, action taken: ____

ROTOR SINGLE-PHASE TEST:	Good	Bad		
SURGE TEST	Yes	No		

If bad, action taken: ____

ROTOR:	Rebuild	Rewind	Retreat	Clean and Paint
ARMATURE OR FIELDS:	Rewind	Retreat	Clean and Paint	
LEADS:	Repair	Replace	Seal	
BRUSH HOLDERS:	Reinsulate	Repair	Replace	Clean
SLIP RINGS:	Repair	Rebuild	Replace	Turn
METAL WORK:	Housing	Journal	Other:	
ANTIFRICTION BEARINGS: (Indicate type:)		Sealed	Shielded	Open
SLEEVE BEARINGS:	Rebuild	Replace	Scrape	Reinsulate
BEARING SEAL:	Rebuild	Replace	Remachine	Reset
FRAME SEAL:	Rebuild	Replace	Remachine	Reset

MECHANICAL INSPECTION FOR MOTORS AS COMPLETED CUSTOMER ______________



TOTAL INDICATED RUNOUTS

DIAGRAM POSITION

OUTPUT A________
OUTER SEAL AREA B________
BEARING FIT C________
INNER SEAL AREA D________
ROTOR BODY E________
ROTOR BODY F________
ROTOR BODY G________
INNER SEAL AREA H________
WDTH_________DEPTH________LENGTH_______
BEARING FIT I________
WIDTH_________DEPTH________LENGTH_______
OUTER SEAL AREA J________
AUX. OUTPUT K_______
ID'S:_______________________________________

VISUAL CONDITION OF SHAFT, BEARING & SEALS

COLLECTOR RINGS — BRUSH SIZE

Collector ring — Brush

Diameter________________Mfg.______________

KEYWAY DIMENSIONS

"A" OUTPUT

"K" OUTPUT

INSTRUMENT

DIMENSIONS & CLEARANCES

INBOARD (PE)			OUTBOARD (OPE)	
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	____________

AC MOTORS

OTHER OR SPECIAL ATTENTION TO:

____

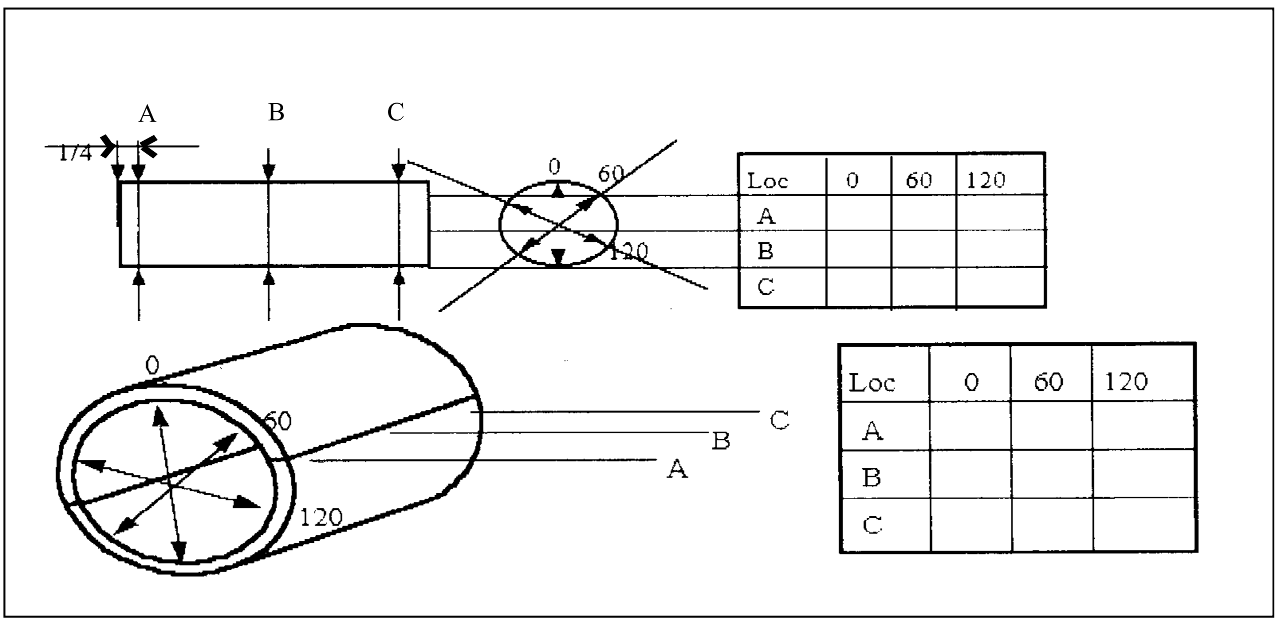
____

____

INSPECTED BY ______________________________ DATE____________________

Appendix F-1

SLEEVE BEARING DIMENSIONS



Appendix G **AC MOTORS**

DYNAMIC BALANCE CERTIFICATE

Vendor ________________________________ Balance Date_________ Time______

Motor Tag # ___________________________ Vendor No. ______________

Equipment balanced ____

Balance Machine Model No. ______________ Last Calibration Date: __________

Balance Machine Serial No. __________________________

Rotor Weight __________________; Rotor "In Service" Speed (RPM) ________

Balance Speed (RPM) __________________________

Radius of permanent balance weight (in.) ___________DE, ______________ODE.

As Found Balance: (oz.in.*) _____________________DE, __________________ODE.

As Left Balance: (oz.in.*) ______________________DE, __________________ODE.

Calculated acceptance limit per journal (4W/N): ___________DE, _________ODE.

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

Count of Rotor Bars: ___________________

Rotor Type:

- Cast Aluminum ☐
- Fabricated Aluminum ☐
- Fabricated Copper ☐
- Wound ☐
- Other _______________________ ☐