<table>
<tr><td colspan="3">INTER PLANT STANDARD – STEEL INDUSTRY</td></tr>
<tr><td rowspan="2">IPSS</td><td>CODE OF PRACTICE FOR REPAIR OF SQUIRRELCAGE HT MOTORS (6.6 kV)
(First Revision)</td><td>IPSS:1-03-023-07</td></tr>
<tr><td>Corresponding IS does not exist</td><td>Formerly :
IPSS:1-03-023-95</td></tr>
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0. FOREWORD

0.1 This Inter Plant Standard has been prepared by the Standards Committee on Rotating Electrical Machinery, IPSS 1:3 with the active participation of the representatives of the steel plants and reputed consulting organizations; and was adopted in May 2007.

0.2 This standard has been made to lay-down the repair practices of HT Induction Motors (6.6 kV) in steel plants. The objective is to provide a procedure for repairs for shop floor people especially apprentice level so that they are assisted with the combined effort of steel plants and consultants in making this standard. This is a base document. There is enough scope of improving this standard. Users are free to send their comments and views to IPSS Secretariat for this purpose.

0.3 The first revision has been carried out to incorporate the experiences of the users in steel plants over the year since the original standard was published.

1. SCOPE

1.1 These guidelines cover the requirement for repair of all 3 phase H T Motors rated for 3.3 & 6.6 kV and upto 1500 kW capacity. Generally motors of capacities falling in the frame size 355 to 1000 come within the range of this standard.

2. GENERAL

2.1 The damage to motor, users normally come across are as under:

a) Stator winding burnt or earthed.
b) Damage to core at the spot of shorting of winding with earth.
c) Rubbing of rotor core with stator core and consequent damage to cores.
d) Loose wedges and overhang packings resulting in movement of coils.
e) Failure of insulation of terminal leads; causing earth fault or open circuit.

The following defects of a mechanical nature are also seen:

i) Loose bearings on shaft.

ii) Loose bearings/bearing-capsules in end covers.

iii) If the bearings are having insulated capsules on the NDE side, bearings get damaged due to failure of insulation.

iv) Broken copper/brass rotor bars, broken at either at the joint with end rings or inside slots. The broken ends can damage the stator winding also.

v) Disturbed air gap for motors on journal bearing due to wearing out of bearing metal or bearing failure can lead to rubbing of rotor core with stator core resulting in damages to stator winding.

vi) Broken cooling fan or heat exchanger failure.

vii) Bent shafts.

3. REASONS FOR FAILURE OF STATOR / ROTOR

a) Over loading of stator due to mechanical overloading or jamming of rotor.

b) Voltage surge in the system either due to switching operation or earth fault in the supply system (This is more pronounced in unearthed supply system).

c) Inter-turn/Inter-phase short circuit in the Stator winding mainly occur in the overhang portion.

d) Rubbing of stator core with rotor core due to:

- i) Heavy fault currents
- ii) Failure of bearings
- iii) Loose bearing capsules
- iv) Loose fitting of end covers
- v) Looseness of stator or rotor cores on their mountings.

e) Loose wedges and consequent movement of coils leading to failure.

f) Loose bindings of intercoil packing and loose binding of coils with supporting rings, leading to movement of coils during switching or during voltage surge in the system (Such voltages are more pronounced in unearthed supply systems).

g) Broken bars of rotors due to strong jerks and overheating of the rotor bars due to frequent switching operations. Bars also get broken due to poor brazing of rotor bars with the end rings. Butt welded rotor bars have a greater tendency to break rather than the bars sitting on end rings. Looseness of bars in the slots also leads to breaking of bars.

h) Continuous vibration in the motor due to loose foundation, unbalanced rotor, misalignment, unequal air gaps, broken rotor bars, displaced balancing weight in rotor, broken internal fan etc.

j) Clogged ventilation holes inside and outside stator body can lead to overheating of winding.

k) Entry of foreign objects or water and oil.

4. REPAIR PROCEDURE

4.1.1 The following data shall be noted:

a) Name plate details of motor.

b) Type of winding including class of insulation of materials employed.

c) Length of overhang on both sides.

d) No. of slots and No. of poles.

e) Coil overhang supports provided and their distance from core.

f) Inter coil packings and their method of tying.

g) No. of wedges per slot, their material and configuration.

h) Coil pitch.

j) Number of parallel connections and layout of coil jumpers and their bindings, including size and material of packings.

k) Location of incoming leads and their position including their size and length.

m) Details of slot insulation and intercoil separators.

n) Y or connection.

p) Number of terminals brought out (3 or 6) and their location on the stator body.

q) Location of thermistors inside winding, if provided, is to be noted. Originals to be preserved to know their type, size etc. for replacement of defective ones.

r) Note if any corona discharge paint is applied on coil or insulation. Note the details of graphite paper (slot insulation) wherever provided.

s) Any other relevant information.

4.1.2 Checking of Stator Core and Repairs :

a) While removing coils from slots, care should be taken to use just enough force to prevent damage to the stampings.

b) If core pressing steel fingers are employed at either end of stampings, their tightness should be checked. The fingers should be rewelded wherever necessary.

c) All core holding bolts running longitudinally along the core length should be checked for their tightness.

d) The stator slots should be cleaned with a knife or similar instrument to remove all the insulating materials that may be sticking to the core.

e) All the radial ventilation holes are to be thoroughly cleaned to remove mud, pieces of stones and other extraneous matter.

f) Wash the core with suitable cleaning agents including steam-water injection and allow it to dry.

g) After cleaning the stator, check for shorts in the stator core stampings by conducting flux test. The test is conducted by passing current through 1-2 turns of heavy conductor cable wrapped through the stator bore. Pass current of 200-300 Amps from a welding transformer for about 15-30 minutes. (If a high frequency source of supply is available, the passage of current could be of shorter duration.)

If localized hot spots are felt when the hand is moved over the core, it indicates local shorting of stampings and needs repairs. The stampings are to be individually isolated and insulated by applying core insulating varnish and drying in a furnace. Flux test should be repeated to ensure a short-free magnetic circuit. If hot spots persist, there is no alternative other than resorting to restacking of stampings.

NOTE : If necessary, increase the number of turns of cable and increase the current to obtain atleast 15-20^{o}C rise of temperature. Some times the hot spot temperature-rise can be established only after keeping the supply on for 12-24 hours.

4.1.3 Rewind the stator as per the original data and construction of winding.

4.1.4 Carry out necessary test on the stator. Dry the stator in an oven at 100^{o}C for atleast 8-12 hours prior to impregnation.

4.1.5 Impregnate the stator winding twice and dry at the prescribed temperature and for a period as applicable to the varnish employed. A coat of epoxy red gel varnish will build a non-corrosive surface on the winding.

NOTE 1: If facilities exist, dip impregnation gives excellent results. Otherwise the varnish is to be poured well on the winding till it is fully soaked.

NOTE 2: If epoxy moulded coils are used, a coat of epoxy red gel coat will suffice.

4.2 Test Procedure During and After Rewinding of Stator :

4.2.1 High Voltage Test :

a) A few coils, chosen at random, are to be subjected to H.V. test prior to placement in slots. The coils can be fixed in slots and tested or a tape of aluminium foil can be wound on the limbs of the coil (on the core area) prior to H.V. test.

b) During the process of placement of coils, H.V. test is to be conducted in batches of 8-10 coils. All coils not under test are to be kept earthed during the test.

c) After placement of all coils and rewedging, H.V. test is conducted.

The High voltage applied should be as per the following norms adopted for a 6.6 kV rated machine:

	Stage	High Voltage
1.	Prior to placement in slots	19 kV
2.	During batch placement of coils in slots	16 kV
3.	After placement of all coils and after rewedging	14.2 kV

NOTE : i) All the values quoted above are ac, RMS, 50 CPS.

ii) Megger test after rewinding: The IR value should not be less than 5 M-Ohms. The absorption factor R60/R15 should not be less than 1.3.

iii) The winding is to be subjected to drying in an oven for atleast 6-8 hours at 80-100 ^{o}C.

d) Stator coils, prior to their placement in slots, are to be subjected to impulse test for determining inter-turn short circuits.

e) Magnetic Field Test :

An uniform rotating magnetic field should be obtained when a 3 phase ac supply is given to winding. This can be checked with a magnetic compass. The needle should rotate uniformly when held close all round the core.

f) Polarity Test :

This shall be as per the rated speed of the machine. This can be conducted by giving supply to two of the phases. The number of poles formed can be checked with a magnetic compass.

g) Current Balance Test:

The rated 3 phase current shall be passed for checking the balanced current in all the three phases of winding. After the passage of current for a reasonably long time, switch-off the supply and feel around the winding and connection joints for any `hot-spot'. Rectification is to be carried out wherever necessary.

4.3 Repair of Rotors

4.3.1 Repair agencies come across damage to both single cage and double cage rotors. While it is possible to repair broken bars of single cage rotors, it is not possible to carry out repairs to bottom cage of double cage rotors.

NOTE : Aluminium diecast rotors are generally not used in H.T. machines.

In single cage rotors, breakage of bars from the end ring is most common, though occasionally we come across bars broken inside slots.

a) If the break is at the end ring, drill a hole through end ring and the bar. Put threads in the ring and the bar and fix a screw. Braze all around with silver solder.

b) If a spare bar is available, the broken bar can be totally replaced.

c) If the break is inside the slot, replace the broken bars with identical bars of same size and composition. If sufficient length is available, the rod should be made to sit on the end rings rather than butt against it. This way a stronger joint is obtained.

NOTE : The rotor slots are to be thoroughly cleaned and all molten deposits should be removed prior to replacement of broken bar.

4.3.2 Whatever the mode of repair, it should be ensured that the bars are fully tight inside the slot. Caulking of bars all along the length will help in tightening them (This is possible only in bottle shaped profiled bars).

4.3.3 Even if a few bars are repaired or replaced in a motor of 750 rpm or above, it is necessary to check the dynamic balance of rotor on a balancing machine.

4.3.4 The internal and external fans need inspection to detect broken fins, loose rivets etc. If the fan is taken out for repair, its position should be well marked on rotor so that it goes back to its original position. Displaced mounting can cause unbalance in the machine as balancing weights are sometimes fixed on fan fins and any change in position causes unbalance.

4.4 Loose Bearings on Shaft - In the case of motor fitted with antifriction bearings the problem can be rectified by depositing metal on the worn out area and machining to correct size. A low heat electrode is recommended for depositing metal. While depositing metal, care should be taken to deposit alternate points, 180 degree opposite, around the periphery to avoid bending of shaft. The worn out area of bearing seating needs to be under-cut by 0.5 to 1 mm prior to the deposition of metal. In respect of motors with sleeve bearings, the following repair practice is to be adopted:

(a) In respect of bearings with small wear out upto 1 mm (in dia), the journal neck should be machined on a lathe and polished by grinding to achieve a 6 surface finish. The bearings are to be built as per the new dimensions of the shaft.

b) In respect of bearings with major wear out, the procedure as mentioned for antifriction bearing seatings can also be adopted by depositing metal using low heat electrodes. After machining the surface and obtaining as close a finish as possible, the final polish is obtained by using emery cloth.

c) If the result obtained by either of the methods at (a) & (b) above is not satisfactory, the only alternative is to replace the shaft itself.

4.5 Loose Bearings/Bearing Capsules in End Covers - This can be repaired by enlarging the bore of the end cover or bearing capsule by 5-8 mm (depending on the size of the machine). Fix a sleeve in the enlarged bore and machine to match OD size of bearing. Lock the sleeve in position with screws to prevent rotation.

Loose bearing capsules are repaired by depositing metal on the outer surface of capsule and machining to match bore dimensions of end cover.

4.6 Repair of Insulated Bearing Capsules

4.6.1 Bearings sometimes fail due to heavy shaft current. In some designs, the non-drive end (NDE) side is insulated to block this current. When the insulation fails, the bearings may suffer damage due to shaft currents. Insulation is generally provided on the outer surface of the bearing capsule.

4.6.2 Procedure for repair of bearing insulation :

a) Remove old insulation after noting the details.

b) Wrap resiglass tape on the outer surface of capsule to the desired thickness (allow some machining allowance) at a tension of 100 kg/cm^2

c) Cure the insulation in a oven at 150 ^oC for 12 hrs.

d) Machine the capsule to desired size.

5. TEST PROCEDURE FOR REPAIRED MACHINE

5.1 Compulsory Tests

a) Megger test (with 2.5 kV megger)

b) Resistance test

c) No load test (for checking the condition of bearings and current balance. Preferably DOL starting to be done on test bench)

d) Bearing temperature and vibration measurements.

5.2 Optional Tests

e) Load test of the motor

f) Interturn insulation test with impulse surge tester or using similar devices

g) Any other specific test that the customer may specify.