



EXTERNAL REPORT

ON

MAINTENANCE SCHEDULE CHECKLIST

FOR GEPC - RM COMMISSIONING & SERVICES

ALL RANGES OF MOTORS INSTALLED BY GEPC

Change Number:	Change Number
Author:	Muthukkumaran, S
Design Office:	
Reason for new issue:	General Update
Document Export Control, Source of Original Technology:	
Document Export Control Tag:	Not Tagged

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. The information contained herein is GE Energy Power Conversion Proprietary Technical Information that belongs to the General Electric Company, GE Energy (USA), LLC and/or their affiliates, which has been provided solely for the express reason of restricted private use. All persons, firms, or corporations who receive such information shall be deemed by the act of their receiving the same to have agreed to make no duplication, or other disclosure, or use whatsoever for any, or all such information except as expressly authorized in writing by the General Electric Company, GE Energy (USA), LLC and/or its affiliates.

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 1/54



CONTENTS

1. INTRODUCTION.....	4
1.1 SCOPE OF THE DOCUMENT	4
1.2 LIMIT OF RESPONSIBILITY AND WARRANTY CONDITIONS.....	5
1.3 RELATED REFERENCE DOCUMENTS.....	5
2. IMPORTANT INFORMATION ABOUT THE CHECKLIST	5
2.1.1 Maintenance support.....	7
2.1.2 Prerequisites to perform maintenance.....	7
2.1.3 Maintenance and inspection proof requirements.....	7
2.1.4 Alterations, Modifications, and Replacement Parts.....	8
3. BASIC SAFETY INSTRUCTIONS.....	9
3.1 EXPLANATION OF THE SYMBOLS	9
3.2 APPLICABLE REGULATIONS	10
3.3 COMMON HAZARDS.....	10
3.4 SPECIAL DANGERS – ELECTRIC POWER.....	11
3.5 GUIDANCE NOTES FOR USERS ON THE SAFETY OF PERSONNEL.....	12
3.6 LOTO.....	13
3.7 SKILLS REQUIRED FOR SPECIFIC TASKS.....	14
4. PRODUCT DATA.....	15
5. OVERVIEW OF THE MAINTENANCE WORKS	16
5.1 MAINTENANCE INTERVALS	16
5.2 SCOPE OF MAINTENANCE	17
6. REGULAR MAINTENANCE (OR 1ST LEVEL MAINTENANCE)	19
6.1 STANDARD VISUAL INSPECTION	19
6.1.1 Visual Checks (off-line)	20
6.1.2 Terminal Cubicle Inspection.....	20
6.1.3 Frame and Stator core physical inspection.....	21
6.1.4 Rotor and Field physical inspection.....	21
6.1.5 Bearing Inspection and Re-lubrication tasks.....	21
6.1.6 Bearing Sealing Inspection	22
6.1.7 Stator winding inspection	22
6.1.8 Cooling Circuit and Heat Exchanger Inspection.....	22
6.2 STANDARD CLEANING (OR DUST REMOVAL) TASK	24
6.2.1 Clean the exterior of the motor	24
6.3 STANDARD FUNCTION TESTS	25
6.3.1 Brief Test Descriptions	25
6.3.2 Motor Running Tests (Online).....	26
6.3.3 Motor Static Test (Off-line).....	26
6.4 MOTOR MONITORING & DIAGNOSIS	26
7. ENHANCED TECHNICAL SUPPORT	27
7.1 MOTOR CIRCUIT TESTING	27
7.2 ADVANCED TESTING, MONITORING & DIAGNOSIS SOLUTIONS.....	27
7.2.1 Digital Diagnostic Management Solutions.....	28



7.2.2	Vibration Analysis.....	28
7.2.3	Thermography Services	28
7.2.4	Motor Reliability Program.....	29
7.2.5	Motor Performance with GE patented Condition Forecaster™ Monitoring System.....	29
7.2.6	Remote Monitoring & Diagnostics (RM&D) for Motors.....	30
8.	REPAIR & REFURBISHMENT WORKS.....	31
8.1	MOTOR MAINTENANCE AND REPAIR SERVICES	32
9.	FAULT FINDING	33
9.1	FAILURE TO START OR ACCELERATE.....	33
9.2	VIBRATION	33
9.3	MECHANICAL NOISE	33
9.4	MAGNETIC NOISE	33
9.5	WINDING OVERHEATING.....	34
9.6	BEARING OVERHEATING	34
9.7	LEAKAGE OF OIL.....	34
9.8	BRUSH HEATING.....	35
9.9	COOLERS	35
10.	RECOMMENDED MAINTENANCE TOOLS.....	36
10.1	SEFETY EQUIPMENT.....	36
10.2	TYPICAL MAINTENANCE TOOLS	36
10.3	MOTOR ALIGNMENT TOOLS	36
11.	MAINTENANCE SCHEDULE	37
12.	GLOSSARY OF TERMS	40
13.	APPENDIX A.....	41
13.1	MAINTENANCE REPORT.....	41
14.	GE POWER CONVERSION CONTACT DETAILS	53
15.	MODIFICATION RECORD.....	54



1. INTRODUCTION

An effective motor maintenance program is a preventive and corrective maintenance schedule that begins with reviewing a motor's service history. This review may reveal on-going problems that are both integral to the motor itself as well as external conditions (e.g., overloads, unbalances, misapplications) that are adversely affecting the motor's normal operating condition. Once regular maintenance checks are incorporated into a shop's work schedule, they soon become transparent yet will secure cost-savings well beyond the investment in time and materials spent in maintaining them.

The maintenance concept is aimed at reducing the probability of failure or damage to the motor under intensive use and under the environmental operating conditions at the site.

The various preventive maintenance actions must therefore be programmed to ensure:

- the operational availability of the motor in accordance with the functional requirements, at optimum cost efficiency,
- the operational safety of the motor, personnel and environment in observance of the applicable regulations,
- the forecast service life of the asynchronous machines.

Failure prevention must therefore be covered by a preventive maintenance task schedule defined in accordance with the various functionalities of the motor components and predefined criteria relative to their state of deterioration.

This section gives general recommendations aimed at maintaining the functional reliability of the motors. The maintenance actions recommended are not all-inclusive as each site will have its own special operating features. By intensifying and continuously developing maintenance and monitoring, enhanced motor reliability will be ensured.

1.1 SCOPE OF THE DOCUMENT

This maintenance checklist is intended for the GE Field Service Engineers to assist our GE Customers. It provides all the essential scope information for safe maintenance, cleaning, inspections, testing and replacement tasks that are necessary to ensure the proper operation of motors and associated equipment. The term motor used in this checklist refers to all kinds of motors GE produced which are stated in Section 4 in this document.

We, GEPC are committed to supporting all generations of motors installed by us under our various previous names including



As a service to loyal customers to your shop, provide them with a do-it-yourself maintenance checklist. This should include ensuring that the motor is kept free of dirt and debris and examining drive belts for signs of



excess wear. Only qualified technicians or engineers, who understand the principles of operation of the motor and its Control Panels, shall carry out the maintenance.

Personnel intervening on the motor must be completely familiar with information and instructions contained in this checklist. In the event of any contradictory information between the various documents covering the motor, the specific contractual documents shall take precedence over the checklist, except as concerns the information stipulated in paragraph "1.2. Limit of responsibility and warranty conditions".

Should any differences be observed on the equipment with respect to this checklist, the user shall make the decisions which he may deem necessary, in accordance with the user's engineering skills. Should any incomprehension or doubt remain, the user should contact Power Conversion Services Department.

1.2 LIMIT OF RESPONSIBILITY AND WARRANTY CONDITIONS

GE Power Conversion shall not be held responsible for any consequences, direct or indirect, resulting from incorrect reading or interpretation of this checklist. Failure to observe the instructions given in this checklist will cancel the motor warranty. In such a situation, Power Conversion shall not be held liable for any reason whatsoever.

The warranty is limited solely to conformity of the motor with the contractual specifications. The warranty shall only apply provided the motor is used in compliance with the contractual specifications and in strict observance of the information and instructions given in this checklist. The warranty obligations shall be cancelled should any motor be modified or repaired without the prior written approval of Power Conversion.



NOTE

The warranty will only be effective provided the instructions given in this checklist are thoroughly and strictly observed and provided the installation report has been submitted to GE Power Conversion as required

1.3 RELATED REFERENCE DOCUMENTS

1. Motor Environmental, Health and Safety Manual
2. Installation, Operation, and Maintenance Manual
3. Spare Parts List
4. Bolt tightening torque requirement List
5. Lubrications List

In addition, where referenced, check for updates to any vendor maintenance requirements

2. IMPORTANT INFORMATION ABOUT THE CHECKLIST

The instructions in this Checklist are minimum requirements for maintenance of the GE Motors. These instructions may not cover all variations in equipment, or provide for every possible contingency in connection with performing maintenances. Depending on the operating conditions and environment, extra work may be necessary to maintain the specified condition of the Motor System.

Pictures used in the checklist are generic and may not be indicative of your specific configuration.

Certain tasks identified as 'optional' or 'if equipped' refer to an optional motor test which may or may not be applicable to other ranges of motors. Refer to the specific motor configuration to determine task applicability.



The owner of the Motor is responsible for ensuring all required maintenance is performed and properly documented. If a contracted party is performing maintenance we advise reviewing your maintenance contract to determine what elements are included.

This checklist incorporates all range of motors equipment. Many sections are mainly applicable to the LV/MV induction motor equipment and many others are applicable to either Synchronous or DC motors. Some sections may explain explicitly between the three configurations, but have different requirements for each.

The following table outlines that difference in each construction, working principles and service's needs:

LV/MV/HV Voltage AC Asynchronous Motor Sections	MV/HV Voltage AC Synchronous Motor Sections	DC Motor Sections	Common variance in construction or major accessories
Stator Frame with wound poles	Stator either wound or Permanent Magnets	Yoke, Adjustable stator poles No field winding on PM Stators	Horizontal or Vertical mounting
Either Wound or Squirrel cage Rotors	Wound Rotors only No rotor bars for field	Wound Rotors only	Shaft coupling
Total 3 or 6 terminals - 3 for stator and 3 for rotor slip rings	Total 5 Terminals - 3 for stator & 2 for rotor slip rings DC field supply required.	4 Terminals - 2 for armature & 2 for field. Sometimes 2 additional for shunt field	Terminals cabinet type and position
A modified Universal motor has brushes & commutators (for use as power tool drives like drills, cutters, grinding mill motors, etc.)		Rotor have Commutators & carbon brushes always	Excitation & control
The speed of the A.C. motor is controlled by varying the frequency, which is commonly done with an adjustable frequency drive control		The speed is controlled by varying the armature winding's current	Geared motor system
Case Ventilation or Cooler exist		No ventilation	Air or Water cooling

Maintenance and repair work may only be carried out by trained technical personnel in accordance with all local and national requirements and standards. For safety reasons, you may enter the motors inside only when supported by a second person, so that help can be provided and called for in the case of an emergency.

When handling grease, oil, and other chemical substances, you must observe the applicable regulations and safety data sheets of the manufacturer of these substances with regard to storage, handling, use and disposal. Ensure that the consumables, the process materials and the replacement parts are disposed of safely and in a compliant and environmentally friendly manner!

This includes but is not limited to the following items of concern:

1. operation of motors is not functioning as stated within the Operating Manual, or other applicable GE Energy documentation
2. liquid (e.g. coolant) leaking from a cooler component
3. cable insulation cracking or excessive wear
4. loose connections (typically found when troubleshooting)
5. operation of motor (e.g. braking sound) is different than the other equipment of the industry

For questions regarding conspicuous items, please contact the local GE Service Provider.



2.1.1 Maintenance support

If there are any questions regarding the requirements of this checklist, operation of the motor, safety warnings, or a specific condition of a motor please contact your GE Power Conversion representative.

While performing the maintenance, communicate any discrepancies and abnormalities (i.e. cracks, damage, excessive pitting, missing or broken hardware, etc.) to your local GE Service Provider.

2.1.2 Prerequisites to perform maintenance

All kinds of motor maintenance require pre-maintenance planning and scheduling. This starts with reviewing the motor's service history usually contained within an equipment maintenance log or, if the log is not available, interviewing the customer, operator or responsible party to determine what type of maintenance is required, preventative or corrective (failure repair). The goal is to determine:

- What kind of maintenance is required?
- What maintenance personnel are needed to perform the maintenance (skill level)
- What parts are needed to complete the maintenance (i.e., bearings, brushes, etc.)
- What kind of scheduling or coordination with other departments is required to perform the maintenance (downtime or off-hours scheduling)
- What kind of safety hazards exist that would interfere with the maintenance.
- If there are problems other than the motor itself that caused the motor breakdown.

2.1.3 Maintenance and inspection proof requirements

The Maintenance and Inspection Proof issued with the checklist is a prerequisite for operation of the Motors may be requested as a prerequisite for warranty approval. The proof is included as **Appendix "A"** and is the minimum required information to record proof of maintenance.

Conspicuous items or other items of concern must be recorded on the Maintenance and Inspection Proof. You are also advised to contact your GE Power Conversion representative. Failure to do so in a timely fashion may impact safety of personnel, motor performance, component reliability and warranty claims.

Examples of conspicuous items include but are not limited to:

- Items which raise a safety or component reliability concern (vibration, noise, weld cracks, excessive wear or corrosion)
- Electrical component arcing /heat damage, cable insulation cracking /excessive wear
- Abnormal condition of drive train components (coupling slippage, gearbox or motor defects)

A maintenance record can be used for the following purposes:

- Verifies that equipment is routinely checked
- Aids troubleshooting and prevention of equipment failure by providing a history of equipment maintenance and problems

Every day records

- a) At what time (year, month, day and hour) and in what weather the test is conducted .
- b) Voltage. load current . frequency.
- c) Ambient temperature (room temperature).
- d) Temperature and noise around bearings.
- e) Temperatures in stator windings and on frame surface (totally enclosed type).



- f) Abnormal vibrations and noise

Records of periodical test and inspection

- a) Insulation resistance and the relative humidity
- b) Amplitude of vibration
- c) The color and contents of grease discharged from bearings.
- d) Dirt lodged in and on the motor.
- e) Coupling allowance of coupling device; the tension of belts.
- f) Fastening bolts for base, foot and other parts.
- g) In case of oil lubrication, surface condition and clearness of the oil should be recorded. At the same time, check and make sure there is no leakage.

Some of the values obtained by above-listed tests and inspections are variable; their variable ranges given below:

- a) The variation of voltage must be within $\pm 10\%$ of rated voltage. The variation of frequency must be within $\pm 5\%$ of rated value. When rated voltage is applied. When voltage and frequency varies at the same time, the result of absolute values of the two variations must be within $\pm 10\%$.
- b) Temperature rise (maximum ambient temperature of 40°C)
- c) Bearing Vibration: In case the vibration measured exceeds the above-specified values, please adopt check and find out the trouble, and corrective measures soonest.

2.1.4 Alterations, Modifications, and Replacement Parts

Alterations to the motor may adversely affect its operation. Alterations could potentially cause catastrophic failures and include life threatening situations. Only those alterations and modifications specifically authorized by General Electric are permitted. Replacement and maintenance parts must meet all technical requirements specified by GE Power Conversion to ensure proper functioning of the motor and its protective systems. Ordering parts through GE Power Conversion will ensure these specifications are met.



3. BASIC SAFETY INSTRUCTIONS

Please observe the Operating Manual and the Safety Manual. Since the motor can be started by the remote control system, it must be shut down and appropriate LOTO applied for maintenance work. The service switch on the control cabinet must also be placed in the "Maintenance" or "Repair" position. The service switch must be placed back in the "Automatic" position after maintenance or repair work has been completed.

Follow the instructions included in these documents as well as all safety signs and marks within the motor. Adhere to all local and national safety requirements and standards.






Never enter or perform work in the Motors without the appropriate Personal Protective Equipment (PPE).

This maintenance checklist is not meant to instruct individuals on the proper operation or the safety requirements of the entire range of GE Motors. Included safety warnings highlight only certain hazards and are not all inclusive. Variations in equipment may pose additional hazards to those highlighted. Individuals / companies performing this work are responsible for understanding the scope of work specified within this checklist and the associated activities necessary such as working at heights, Environment, Health and Safety, etc. They are responsible for determining and enforcing the training and safety standards for performing this work, complying with Local / National regulations, and the guidelines specified in the Operating Manual.

When handling any chemical substance, you must observe all applicable regulations and the manufacturer's safety datasheets of these substances with regard to storage, handling, use and disposal. Ensure that all consumables and materials are disposed of in a safe and environmentally friendly manner.

3.1 EXPLANATION OF THE SYMBOLS

The basic information for technical documentation for Motor is described in the Safety Manual. The following danger classifications and symbols are used in this Maintenance Checklist:

	NOTE Notes include user tips and useful information. All notes should be implemented in the interest of a proper use of the motor.
 Attention	ATTENTION Indicates a procedure, condition, or statement that should be strictly followed to improve these applications.
 Caution	CAUTION Indicates a potentially Hazardous situation which if not avoided could result in a minor or moderate injury or destruction damage.
 Warning	WARNING Indicates a potentially Hazardous situation which if not avoided could result in death or serious injury.
	DANGER Indicates an imminently Hazardous situation which if not avoided will result in death or serious injury.



3.2 APPLICABLE REGULATIONS

Reminder about essential data of explosive atmosphere marking (ATEX/IEC/IECEX):

Manufacturer: GE Power Conversion

Address: 442, Rue de la Rompure

54250 Champigneulle (France)

Type: xxxxxxxxxxxx x / xx

Manufacturing year: 20xx

EC marking: xxxx - xx x x

Marking: xx x x xx xxx xx

Number of EC examination type certificate: xxxxxx xxxxxx xxxxxx

For a reliable use of this machine, particular cautions* have to be taken, including the following complementary conditions:

- The space heater into air has to be switched on when the motor is stopped and cooled down to ambient temperature. The space heater into oil has to be switched on just before motor starting. The space heater must be switched off when the motor is in operation.
- The temperature probes must be connected to a system to monitor the motor and to switch off the motor in case of temperature comes to the trip value.
- All electrical accessories ensuring proper service and safety of the machine shall be of recognized protection mode for the considered use, if they are placed in a hazardous area.


(*): Subject to the installation, maintenance and use in compliance with their destination, the regulation, installation standards in effect (EN/IEC 60079-14) to the manufacturer instructions and good engineering practices.

When the certification standard is EN/IEC (following the standard selected for the certification):

- Installation, maintenance and eventual repairs on the motor have to be executed under appropriated conditions.
- Regarding the risk of electrostatic discharge: when gas group is IIC and the paint thickness on the surface of the material is greater than 0.2 mm, clean with a damp cloth.

User has to take into account external conditions (humidity, salinity, altitude, etc.) and take the appropriate measures to protect the motor. The compliance to these is fully the responsibility of the user.

3.3 COMMON HAZARDS



DANGEROUS CONSEQUENCES FOR YOUR HEALTH AND THE TURBINE!

Always check all work areas and cabinets before concluding the work. Remove all loose parts, tools and materials from the control cabinets. Tools and materials left in the control cabinets lead to unsafe working conditions for the service technicians when the plant is placed into operation.

LIFE-THREATENING HAZARD FROM STARTING THE WTGS BY THE REMOTE CONTROL SYSTEM!

Shut down the WTGS for maintenance work. Place the service switch on the control cabinet in the "Maintenance" or "Repair" position, and ensure the unit is secured from remote start up.



LIFE-THREATENING HAZARD FROM ELECTRICAL VOLTAGE!

First de-energize the electrical equipment to prevent electric shock.



LIFE-THREATENING HAZARD FROM ELECTRICAL VOLTAGE!

Motor components generate electromagnetic fields. Electromagnetic fields have the potential to adversely affect the operation of a cardiac pacemaker or defibrillator. If you have a cardiac pacemaker or defibrillator implanted inside your body, consult your doctor and/or device manufacturer to determine whether or not you are at risk around our equipment. If electromagnetic field measurements are required, then please contact GE for assistance.



DANGEROUS CONSEQUENCES FOR YOUR HEALTH AND THE MOTORS!

For safety reasons, never carry out maintenance work alone.

3.4 SPECIAL DANGERS – ELECTRIC POWER

Working on / near electrical systems pose significant and unique dangers and all personnel must be properly trained on these hazards. Follow all applicable LOTO rules and ensure that all power supplies (including auxiliary) are disconnected, stored energy (capacitors, batteries, etc.) is discharged or isolated, and where appropriate grounding or short-circuiting of the circuit is performed. Be aware that rotating machinery may generate electrical energy even when offline and lock out where appropriate.

Note the following rules when carrying out any work on the electrical components of the plant, e.g. assembly, connection, opening of a device, and maintenance:

1. disconnection
2. secure against re-connection
3. ascertain safe isolation from supply
4. grounding and short-circuiting
5. cover up adjacent live components or provide them with barriers

In addition, ensure that all drives are at a standstill and all stored energy is removed from the system.

LIFE-THREATENING HAZARD FROM ELECTRICAL VOLTAGE!



When energized, electrical installations and machinery may contain live exposed conductors or rotating parts. These could cause personal injury or death and material damage if the cover and/or safety devices are removed, or in the event of improper handling, maintenance, or use. Be sure to comply with the applicable safety regulations.

In addition, electrical energy may still be present in devices even after the supply voltage to the device has been switched off. Be sure to secure such devices from re-energization and access until all stored energy has been removed or discharged. Always check for residual voltage before starting work.

Observe the relevant Lockout/Tagout instructions, the Operating Manual, and the Safety Manual.



DANGEROUS CONSEQUENCES FOR YOUR SAFETY AND THE MOTORS!

Only use fuses with the prescribed amperage! In the case of repairs, care should be taken that design features are not modified in such a way that safety is compromised (e.g. leakage distances and sparking distances in air/approach limits) and that distances are not reduced by insulation materials.

The control system as well as the monitoring and protective functions (thermal motor protection, speed monitoring, fault to ground, etc.) may not be masked or disabled – even during a test run.



CONTROL SYSTEM WARNINGS!

To prevent personal injury or damage to equipment, follow all equipment safety procedures, Lockout Tag out (LOTO), and site safety procedures as indicated by Employee Health and Safety (EHS) guidelines.

This equipment contains a potential hazard of electric shock, burn, or death. Only personnel who are adequately trained and thoroughly familiar with the equipment and the instructions should install, operate, or maintain this equipment.

Isolation of test equipment from the equipment under test presents potential electrical hazards. If the test equipment cannot be grounded to the equipment under test, personnel must shield the test equipment's case to prevent contact.

To minimize hazard of electrical shock or burn, approved grounding practices and procedures must be strictly followed.

To prevent personal injury or equipment damage caused by equipment malfunction, only adequately trained personnel should modify any programmable machine.

Always ensure that applicable standards and regulations are followed and only properly certified equipment is used as a critical component of a safety system. Never assume that the Human-machine Interface (HMI) or the operator will close a safety critical control loop.

3.5 GUIDANCE NOTES FOR USERS ON THE SAFETY OF PERSONNEL

During Maintenance, Testing, etc. ensure that only technically competent and authorised persons are permitted to carry out work and that they:

- comply with statutory requirements
- Isolate the apparatus completely, where possible, before opening enclosures and starting work.
- comply with safe working procedures for the safety of themselves and of others, including the use of temporary barriers and warning notices
- are conversant with the information provided, particularly on measures relating to safety
- recognize the hazards which can arise when working on live apparatus and take all the necessary precautions

Local safety regulations must be observed during erection, commissioning and maintenance of the product. Persons performing this work must be suitably skilled and have been trained to work on this equipment.



CAUTION

Before any work is commenced, the 'Method Statement & Risk Analysis' should have been read and any local site induction courses attended.



The procedures detailed in this document should not be attempted unless they are fully understood and adequate training has been received. Further, the procedures should be followed exactly without any deviation.

No high voltage insulation test is needed in case of damage. This equipment has successfully passed applicable LV/MV/HV insulation test at factory.

Carrying out the protection and safety requests defined in the Low, Medium or High Voltage Regulations that have been established by the regulations from each country, in Force at the time.

WARNING

The following general guidelines are provided for your safety and prevent damage to the equipment. Any work on this equipment should only be performed by suitably qualified, competent and medically fit personnel.

Ensure appropriate PPE is used at ALL times.



- All items exposing high voltage must be placed in a suitable enclosure with restricted access.
- This equipment may be connected to more than one live circuit. Disconnect all supplies before working on the equipment. Follow lock out tag out safety procedure.
- Do not touch any terminal part when electric power is ON. This may cause electric shock.
- In case the product is used erroneously, it may cause serious accidents and death.
- Extinction systems. These transformers should be installed in such a way that the heat generated does not represent a fire risk for the materials nearby.



DANGER

The site lock out tag out procedure must be followed.

3.6 LOTO

Before any work commences, obtain and review the commissioning site Lock out Tag out (LOTO) procedure. Do not continue until the LOTO procedure has been obtained and deemed satisfactory.

It shall be confirmed that no cabinets could be de-isolated without the knowledge of those working on the cabinets. The permit for any work should have its own isolation carried out or if another isolation is in force for other work, reference to all work protected by a single isolation should be made. At a minimum, the procedures detailed in the Health and Safety Manual should be observed.

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 13/54



3.7 SKILLS REQUIRED FOR SPECIFIC TASKS

Information provided in this checklist on the conditions necessary for safety and on any hazards that are reasonably foreseeable during maintenance, together with precautions to be taken to counteract them. However, in certain circumstances, technically competent and authorized personnel may have to gain access to apparatus, which is not completely electrically isolated. Everyone, under whose authority these persons act, is advised to ensure that appropriate safety procedures are generated and are complied with.

The equipment covered by this checklist has been allocated the Apparatus **Grade 3**. Reference to the Apparatus/Task/Skill Level Schedule, enables the user to select personnel to carry out specified tasks.

Skill Level	Job Descriptions	
	Proposed by Supplier	Customer
A	Operating and maintenance staff with NO electrical knowledge	
B	Maintenance staff with SOME electrical knowledge: not permitted to work on live apparatus	
C	Authorized and competent staff (e.g. Electrician, Commissioning Engineer) with HIGH degree of electrical expertise: trained to work on live apparatus and fully conversant with the apparatus.	

Table-1: SKILL LEVELS

Apparatus			Minimum Skill Level Required For		
Grade	Degree of Isolation	Isolation	Setting, Cleaning, Routine Maintenance with POWER OFF	Setting, Routine Testing with POWER ON	Special Testing, Commissioning Fault Finding with POWER OFF
1	Simple 100% Isolation. Requires no electrical knowledge to Isolate.	A	B	C	C
2	Simple 100% Isolation. Requires some electrical knowledge to Isolate.	B	B	C	C
3	100% Isolation possible. Requires expertise, training etc. and knowledge of the apparatus.	C	B	C	C
4	100% Isolation not possible because: <ul style="list-style-type: none"> - Impracticable - Unreasonable - Undesirable 	C	C	C	C
5	Apparatus supplied as loose items chassis etc., for which the customer is responsible for wiring, assembly, etc.	Level of Skill cannot be define by Supplier			C

Table-2: APPARATUS/TASK/SKILL LEVEL SCHEDULE FOR ELECTRICAL APPARATUS

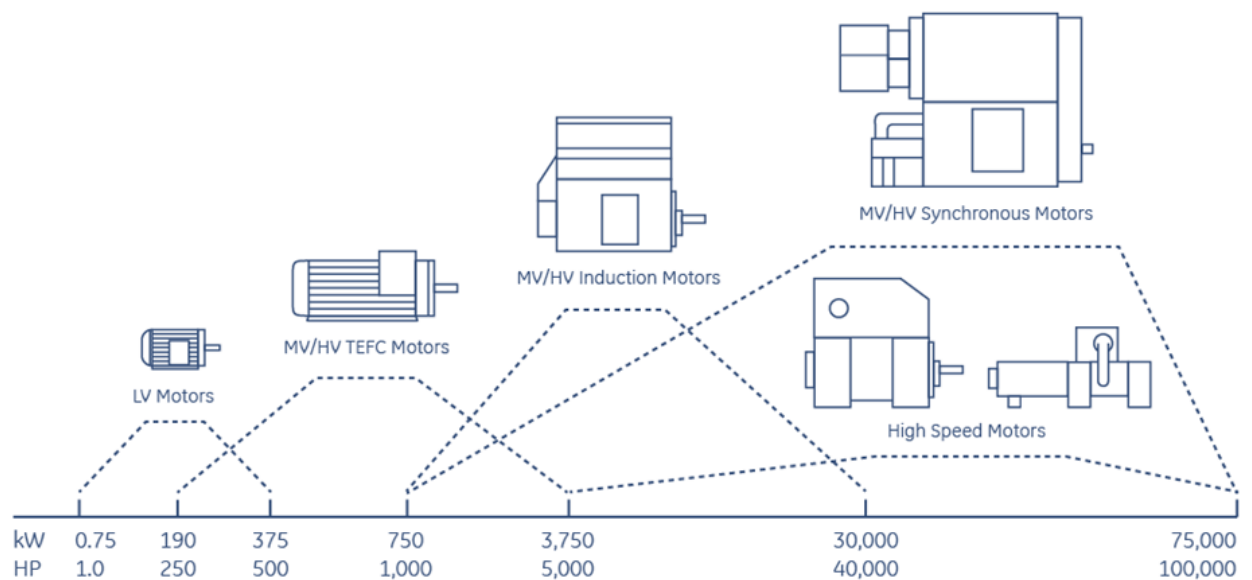


4. PRODUCT DATA

This Maintenance Schedule Checklist covers the entire ranges of motors installed by GE. It includes the following a complete series of the motors for the wide range of applications such as Oil & Gas, Mining, Power & Energy, Cement, Metals, Marine, Pulp & Paper, Water & Wastewater, and Other Process Industries.

- Three Phase AC Induction or Asynchronous motors,
- Synchronous motors,
- DC motors,
- LV / MV / HV Motors
- Low / Medium / High Speed motors
- Vertical and Horizontal Motors,
- Small motors and Large motors

These motors used to drive Fans, pumps, compressors, grinding mills, metal rolling, mine hoists, refiners, marine propulsion and many other applications.



Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 15/54



5. OVERVIEW OF THE MAINTENANCE WORKS

Proper schedule of preventive maintenance helps to prevent, detect, and correct conditions that could cause equipment malfunction. This includes inspections for damage and wear, testing, and cleaning of equipment at regular intervals.



This equipment contains a potential hazard of electric shock or burn. Only adequately trained persons who are thoroughly familiar with the equipment and the instructions should maintain this equipment.

To prevent electric shock while servicing the equipment, personnel must understand and follow all safety requirements for working around dangerous voltages.

Maintenance procedures involve cleaning the equipment and checking for wear and damage through visual inspection and functional testing.



To prevent electric shock, make sure all power supplies to the motors are turned off. Ground and discharge equipment before performing any adjustments, servicing, or other acts requiring physical contact with the electrical components or wiring.

Before performing any maintenance procedures, *the motor must be de-energized*. Do not deviate from the provided *de-energizing* procedures. If safety requirements cannot be met completely, or if you do not understand them, do not work on the equipment.

Circuit breakers, fuses, and electromechanical devices within the exciter cabinet should not be used as lockout devices. Breakers do not isolate wiring and devices on the line side of the breaker, and electromagnetic devices are not positive isolation since they can be electrically operated

5.1 MAINTENANCE INTERVALS

Machines should not be dismantled more often than necessary; it may be possible under good conditions to reduce the frequency of inside inspection and cleaning to once every five years. It is undesirable for the interval to be longer. The required frequency for each procedure depends on:

- How much the equipment is used
- Operating load conditions
- Ambient environmental conditions

Term	Definition
Semi Annual	These tasks must be completed within 6 months of the anniversary or 4,000 operational hour mark of the motor. These tasks are basic and should be completed in addition to any other maintenance tasks due during this period.
Annual	These tasks must be completed by the 12 month anniversary or 8,000 operational hour mark of the motor. These tasks should be completed in addition to any other maintenance tasks due during this period such as the semi-annual maintenance tasks and any special maintenance tasks due such as oil changes.
Beyond Regular Maintenance (BRM)	Those tasks that occur at an extended, infrequent or irregular manner such as oil changes, converter coolant exchange, anchor bolt tensioning, etc. These tasks should be completed at the frequency specified within the pertinent maintenance checklist section, as called for within the vendor's manual or as directed by GE engineering.

Table-3: MAINTENANCE INTERVALS



Unless otherwise specified by contract, a general inspection should be carried out at least two times per year (or after 4000 hours of operation). If the machine is in use daily, GE recommends that inspection of the machine at standstill shall be performed at intervals of approximately EVERY THREE MONTHS without dismantling anything.

Certain maintenance tasks may be moved to occur at any maintenance cycle to accommodate site needs but must be completed within the specified period. Examples are the High Wind and Low Wind checklists.

We strongly recommend that Customer shall contact on Power Conversion's expert services for assistance in isolating the causes of a malfunction and the procedures to be applied when a malfunction is observed. All work performed must be logged in a maintenance record; this work record will be useful to both the customer and the manufacturer.

5.2 SCOPE OF MAINTENANCE

S.No.	Maintenance Activity	1 ST Level	2 nd Level	3 rd Level
		Semi-annually (every 4,000 hrs of operation)	Annually (every 8,000 hrs of operation)	Beyond Regular Maintenance (Every 5 Years i.e., 40,000 hrs of operation)
1	Regular Maintenance	<ul style="list-style-type: none"> ✓ Standard visual Inspection, ✓ Standard cleaning tasks and ✓ Standard functional tests 		<ul style="list-style-type: none"> ✓ Complete Visual Inspection ✓ Advanced cleaning (if required) ✓ Additional major tests if required.
2	Mechanical Disassembly & Overhauling	-	✓ Open inspection of motor subassemblies	✓ Disassemble and Overhauling of major parts such as rotor
3	Enhanced Technical Support (On-request only)	-	-	! Optional Tests <ul style="list-style-type: none"> - Air gap checking & correction - Rotor balancing - Thermographic test - Inter-laminar Insulation test - Any special measures related to explosive hazards such as Arc flash Hazardous analysis
4	Repair / Refurbishment (On-request only)	-	-	The following tests shall be performed additionally after any refurbishment: <ul style="list-style-type: none"> ✓ Turn-to-turn test ✓ Tightness of HV connections
5	Monitoring & Diagnostics (On-request only)	-	✓ GE shall conduct a spectral Analysis to detect various malfunctions if occur	! This calls for specialised know-how, covering all preventive & corrective maintenance actions if required. <ul style="list-style-type: none"> ✓ Stator wedge Insulation tightness
6	GE Specialized Maintenance tasks (On-request only)	-	-	! Digital Diagnosis Management Solutions ! Motor performance monitoring with GE's patented condition forecast system ! Motor reliability tests
7	Modify/Upgrade	-	-	! On-request only
8	Spares List	-	-	✓ As recommended
9	Training	✓ As agreed through service orders		
10	Reports / Documentation	✓ To be submitted as per the service order agreement.		






Term	Task Type Definition
Regular Maintenance Care for the Customer needs	<p>At GE, we understand that the goals of your organization are demanding, and evolving. To help you meet these goals here at GE Power Conversion we provide a service that goes beyond just waiting for your call.</p> <p>We offer a comprehensive range of aftermarket services including replacement units, field services, spares, service agreements, unit upgrades and technical support. Our mission is to satisfy our customers aftermarket needs.</p>
Disassembly & Overhauling	GE installs the equipment with confidence. Our team of field service engineers are on hand to ensure your assets go into active service functioning efficiently
Visual Inspection & Cleaning	Inspection by technicians eyes of the proper condition of installed equipment. This can include cleaning of the motor to allow proper inspection or use of a tool such as a boroscope to inspect the internals of such components as the windings. Visual inspection of torque markings will fall under this section
Function Test	A physical measurement of a motor or check of proper operation of installed equipment. This uses the technician's hands for simple operation through more sophisticated test equipment such as thermographic imaging equipment.
Diagnostics and Specialized	Delivering state of the art test and diagnostic services, our specialist field engineers will apply our in house analysis tools to analyse the asset's performance. We work together with the customer to resolve those issues on installations in the field efficiently and reliably
Enhanced Technical Support	We offer enhanced technical support to customers with service agreements. Our enhanced technical support agreements are designed to suit your specific needs including the availability of 24/7 on-call technical assistance, remote support and immediate mobilization to emergencies
Lubrication Task	Testing, measuring, adding or exchanging oil, grease or coolant within motor components. This is typically associated with fluids that are maintained in bulk quantities. It does extend to the replacement of oil filters.
Torque Requirement	The physical application of torque specifically to fasteners which are particularly critical to the operation and safety of the motor. These tasks are typically not performed on fasteners that have been treated with thread locking compound.
Repair / Replacement / Refurbishment	Items within the motor are replaced as an expected wear item such as filters, grease cartridges and bearing seals. Any items that end up being replaced, but not specifically called out as a replacement task, are a result of defects found during other inspection steps and are repairs of defects and not maintenance items themselves.
Modifications and upgrades	To extend the life of your asset, our engineering design team will provide you with suitable upgrade options aligned to meet your technical specification and requirements to improve
Spares and Consumables	The GE Parts team is available to advise the appropriate spares and consumable parts for you to hold in stock. For those emergencies the team will provide the parts you need on time and at the quality you expect
Training programs	Through our in-depth training modules we provide our customers with the knowledge and skills to operate and maintain equipment in the field
Documentation	As part of the service, customers will receive a Final Report documenting the results of the electrical tests and visual inspections performed, as well as both immediate and long term recommendations. Recommendations related to spare parts, future repair needs and additional proposed inspection schedules are also included.



6. REGULAR MAINTENANCE (OR 1ST LEVEL MAINTENANCE)


6.1 STANDARD VISUAL INSPECTION

Prior to start up the Maintenance; discuss with the customer any existing/previous issues with the motor.

 Caution	CAUTION! Care should be taken that no live parts should be accessed without isolation of AC Breaker as it contains Electrical danger
	DANGER Life-threatening hazard from electrical voltage! Prior to working on the motor, the unit must be completely de-energized and isolated for safety in accordance with local and national regulations. Observe the relevant Lockout/Tagout instructions. Wear appropriate PPE for entrance into energized cabinets. Due to the design of the motor (permanent magnet excitation) a high voltage is generated at the stator winding when mechanically rotating the machine! Never open the terminal box or work on the installation while the machine is rotating! The (high-speed if equipped) rotor lock must be applied prior to working on the motor with exception of manual bearing greasing tasks.
 Warning	WARNING Dangerous consequences for your health and the WTGS! Only adequately trained persons who are thoroughly familiar with the equipment and the instructions should maintain this equipment.

The schedule should include at least the following items during visual inspection of a motor, wiring and its components before re-applying power.

- Checks that the holding-down bolts are tight.
- Check all visible fixings and bolts, including those holding the cover to the baseplate, the cooler to the cover (if any).
- Inspect the terminal cubicle, bus bar for any insulation failure due to overheating.
- Check for any corrosion of metal parts inside the panels.
- Check for any dust accumulation or or any foreign matter.
- Look for leakage of oil from the bearings along the shaft. Clean around the bearing area, and if the machine has cartridge-mounted bearings, clean around the bearing insulation at the cartridge feet.
- Ensure all covers fitted. Additional protection has been installed where necessary.

	NOTE Visual Inspections and electrical testing will be performed by qualified GE personnel, and all GE and/or site EHS guidelines will be strictly adhered to. Historical records of outage test results should be maintained and compared to the new test results. Changes may point to needed repairs and/or rework that may not be evident from the absolute test values themselves. The GE representative shall have access to a detailed maintenance procedure to be followed for each line of preventative maintenance. Customer support is required to ensure full and safe access is allowed
---	--

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 19/54



6.1.1 Visual Checks (off-line)

The following are the standard Visual check requirements:

		Contamination	Cleanliness	Loose or displaced parts	Vibration	Mechanical damage	Deterioration	Corrosion	Surface Condition & Wear	Cracks	Worn parts	Overheating & burning	Corona activity	Tape migration / Irregularities	Broke ties	Radial migration	Core tightness	Dusting and/or greasing	Insulation damage	Ventilation obstructions	Oil/Water leakage	Distortion
Motor Exterior	> Mounting & Coupling (Holding down bolts, Hardware)	X	X	X	X	X	X	X		X	X	X						X		X	X	X
Stator	> Frame (Key bars, Core studs)	X	X	X	X	X	X	X		X												X
	> Core Assembly (Lamination, Finger plates)	X	X	X	X	X	X	X				X				X	X			X		X
	> Slot Section (Slot Fillers, Wedges, Ripple Springs)	X	X	X	X	X	X			X	X	X							X	X		
	> End winding Support System (Bracing, Ties, Coil/Bar Insulation)	X	X	X	X	X	X			X	X	X	X		X			X	X	X		
	> Circuit Rings and Main & Neutral Leads	X	X	X	X	X	X					X	X	X					X	X		
	> Coolers	X	X	X	X	X	X			X											X	
Rotor	> Pole Winding	X	X	X	X	X	X	X	X	X	X	X				X			X	X		X
	> Pole Connections & Leads	X	X	X	X	X	X	X	X	X	X								X	X		X
	> Pole Mechanical Components (Fans, Fan Blades, Keys, Hardware)	X	X	X	X	X	X	X	X	X	X											X
	> Pole coil Winding	X	X	X	X	X	X	X	X	X	X			X	X				X	X		X
	> Slip Rings & Brush Rigging	X	X	X	X	X	X	X	X	X	X	X						X		X		X
	> Pole Supports & Hardware	X	X	X	X	X	X	X		X	X								X	X		X
Bearings & Lube system	> Bearing & Housing Assembly (Bearings, oil seals, greasing system, Auto-lube system, bearing Insulation)	X	X	X	X	X	X	X	X	X	X					X		X	X	X	X	
Ventilation	> Cooling circuit (Cooler, Fan, Filter, pipeline, Instruments)	X	X	X	X	X	X	X	X	X	X									X	X	
Exciter	> Brushes, DC or Static Exciters	X	X	X	X	X	X	X		X	X	X							X			X

Table-4: MOTOR AND ITS COMPONENTS – STANDARD INSPECTION CHECKS

6.1.2 Terminal Cubicle Inspection

- Electrical disconnection of main stator & excitation stator
- Disconnect the rotor earth fault (REFM) (If fitted)
- Check Line/Neutral Side Cubicles. Clean out and check tightness of the links (if not taped)
- Check neutral earthing resistor/transformer. Clean out and check tightness of the links (if not taped)
- Functional checks on cubicle heaters (if fitted)

CLASS II (GE INTERNAL NON-CRITICAL)

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

Revision : 002

Date : 11/07/2017

Page : 20/54



6.1.3 Frame and Stator core physical inspection

- Check the paintwork for damage and recommend course of action if required
- Inspect enclosure for contaminants ingress (water, dust...)
- Check mechanical guards - Coupling/shaft protection (If fitted)

In case of the open machine inspection,

- Check inside frame contamination (oil ingress, fallen parts, debris...)
- Bore scope Inspection of other accessible areas (stator and rotor internals)
- Stator Windings: Check and clean the stator end windings within reach and winding hardware
- Stator core: Check and clean the stator core within reach
- Record air gap clearances

In case of rotor complete removing, inspect entire stator bore, there should not be any damage caused by copper melting from the rotor or friction between them. The stator laminations should not be loose in the frame. The bore of the stator laminations should be true and concentric with the rabbit (spigot) diameter of the frame.

Signs of rub on bore (would also show on infrared inspection during loop test / core test).

- Bent/spread lamination packs
- Missing fingers at end
- Visual swag of air gap if rotor still installed

6.1.4 Rotor and Field physical inspection

The rotor lamination should be of proper fit on the shaft, sleeve or spider on which the lamination stack is assembled. The outer diameter of the rotor laminations should be true and concentric with the bearing journals. Impact stator and rotor for evidence of stator-rotor contact and visual evidence of post-manufacture machining of the outer diameter of the rotor. Cores should be examined for evidence of shorting or lamination hot spots. Testing may be needed.

6.1.5 Bearing Inspection and Re-lubrication tasks

There are different types of bearings and the required maintenance on them will depend on the type of bearing, operating environment and the motor application. There are lubed-for-life, sealed bearings used in low horsepower motors that do not require lubrication.

Lubrication is only one of three maintenance tasks involved with motor bearings. Cleaning, removal and replacement are the other tasks. In the noise and vibration inspections, the bearings should have been inspected for abnormal noises, vibrations or hot bearings. The "feel" and "sound" tests are simple methods to gauge bearing condition. For the "feel" test, with the motor running, touch the bearing housing. If it is very hot to the touch, the bearing is probably malfunctioning. In the "sound" test, listen for thumping or grinding noises. If they exist, the bearings need a closer look and possible replacement.

For most types, the sources of bearing failures are:

1. Insufficient oil or grease
2. Too much grease causing churning and overheating
3. Worn bearings (i.e., broken balls or rough races, etc.)
4. Hot motor or external environment

If the service history demonstrates repeated bearing failures, check the manufacturer's specifications to determine if the correct bearing has been installed. If that's not the case, then an external factor could be the



cause. Prior to bearing removal or replacement, clean the housing with solvents or flushing oils. The bearings should be cleaned with a lint free rag. Take a lot of care to keep dirt out of the bearing. When bearings need to be replaced, remove them with the proper tool. Hammers should never be used since they can damage the bearing races. The bearing puller's claws should be attached to the sidewall of the inner ring or an adjacent part.

6.1.6 Bearing Sealing Inspection







All joints between the various components of a machine are sealed to prevent dust and water getting in, and the internal air from getting out. There are also seals inside the machine to ensure that the cooling air is confined to its proper path and is not allowed to take other paths which would result in less efficient cooling. It is important that all these seals are properly made when the machine is first installed, that they are properly maintained, and that when maintenance is done, and a seal is broken, it is correctly re-made when the machine is re-assembled.

The material used for seals is either expanded silicone rubber strip for non-machined joints, or thin neoprene-bonded cork for machined joints or those where the components are totally flat. Both materials are stuck to one of the surfaces using a silicone rubber adhesive such as Hylosil®.

When maintenance is carried out, the gasket material should be inspected when the joints are taken apart, and new material, together with a supply of adhesive, should be ordered as required, ready for re-assembly. If the machine is duct-ventilated, the duct work seals between sections should be part of the machine maintenance program.

6.1.7 Stator winding inspection

Initial cleaning should be done with a soft brush and low-pressure compressed air. Greasy deposits should be removed by rubbing with a lint-free cloth dampened with white spirit.

	WARNING	
SOLVENTS SHOULD ONLY BE USED IN WELL-VENTILATED PLACES AND CARE SHOULD BE TAKEN WITH REGARD TO NAKED FLAMES.		
	CAUTION	
Do not allow solvents to soak into the windings as this causes porosity of the insulation and allows the penetration of semi-conducting dirt detrimental to insulation resistance.		
	NOTE	
Hardened dirt may be removed by using a fairly stiff brush. Do not use wire brushes or scrape with a knife on windings or leads.		

The stator winding supports and lashings should be inspected for rigidity. After cleaning, the insulation resistance should be tested with a Megger or similar tester. A record should be kept of insulation-resistance readings of the windings, as a trend towards lower readings can be a warning of impending failure. Ensure that comparable conditions exist at each inspection. If abnormally low readings are obtained the cause should be investigated. The windings may need to be wet-cleaned and dried out.

6.1.8 Cooling Circuit and Heat Exchanger Inspection

For motors running continuously day and night, a cooling circuit examination is necessary.

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 22/54



- Check motor air inlet filters (if fitted)
- Check motor air inlet pressure switch (if fitted and accessible)
- Check general status and operation of cooling air fan motors (if fitted and accessible)
- Visual inspection of heat exchangers (no disassembly included)

CACA (IC6A1A6)

1. Check for excessive vibration.
2. Check the bearing temperatures and oil levels. If the bearings are supplied with oil from the prime mover system, check the oil flow.
3. Check the winding temperatures.
4. Check the cooling air temperatures in and out.
5. Check that the cooler fans are running.
6. Check for oil leaks from bearings, seals, sight-glasses and pipework.

The cause of any appreciable change from previous operating levels should be investigated, in case there is a change of circumstances, which requires attention and correction.

If any protection or measuring devices cease to work, report the failure so that steps can be taken for their repair or replacement. Temperature detector elements in the stator winding are not repairable, but spare elements are usually provided and should be wired in as required.

CACW (IC8A1W7)

1. Check for excessive vibration.
2. Check the bearing temperatures and oil levels. If the bearings are supplied with oil from the prime mover system, check the oil flow.
3. Check the winding temperatures
4. Check the cooling air temperatures in and out.
5. Check the water flow to the cooler
6. Check for oil leaks from bearings, seals, sight-glasses and pipework.

The cause of any appreciable change from previous operating levels should be investigated, in case there is a change of circumstances which requires attention and correction.

If any protection or measuring devices cease to work, report the failure so that steps can be taken for their repair or replacement. Temperature detector elements in the stator winding are not repairable, but spare elements are usually provided and should be wired in as required.

All Other Cooling Types

1. Check for excessive vibration.
2. Check the bearing temperatures and oil levels. If the bearings are supplied with oil from the prime mover system, check the oil flow.
3. Check the winding temperatures
4. Check for oil leaks from bearings, seals, sight-glasses and pipework.

The cause of any appreciable change from previous operating levels should be investigated, in case there is a change of circumstances which requires attention and correction.

If any protection or measuring devices cease to work, report the failure so that steps can be taken for their repair or replacement. Temperature detector elements in the stator winding are not repairable, but spare elements are usually provided and should be wired in as required.



6.2 STANDARD CLEANING (OR DUST REMOVAL) TASK



Build-up of dust on electrical components and wiring can damage components and cause mis-operation.

Buildup of dust on components can increase operating temperature, reducing their normal life. On stand-off insulators, dust can collect enough moisture to produce a current path to chassis ground. Dust (especially metallic dust) on wire surfaces can cause tracking between connector pins. Tracking is usually capacitive in nature and involves a buildup of electrical charge along the wire surface. This can cause intermittent problems that are hard to find.

To remove dust from the components

1. Clean stand-off insulators with a clean, dry cloth. Do not use any solvents.
2. Using a fine-filtered vacuum cleaner with a non-metallic nozzle, remove dust and dirt from wiring and electrical components.
3. Inspect cabinet air filters, if equipped. Shake or vacuum filters clean, or replace, as required.

Note Dust is best removed by vacuuming with a grounded vacuum nozzle/brush. A less desirable method is blowing with a low-pressure air source that is filtered and has a water/oil separator.



Do not use high-pressure compressed air, which may damage components.

If a blow nozzle with a tube extension is used, tape the area around the tip of the tube to prevent damage to insulation. When blowing some areas, contamination in other areas may become worse. Cover areas such as the power converter assemblies, boards, and transformers to prevent increased contamination.

4. After cleaning, examine the parts for pitting or other signs of metal deposits on insulation or insulated parts. If parts are pitted, do not reuse.

6.2.1 Clean the exterior of the motor



Wear gloves and eye protection when using cleaning fluids and use them only in a well-ventilated area.



Normal household cleaners may leave a salt residue behind and must not be used.

- If the motor is equipped with air filters, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions. It is better to replace or recondition filters too often than not often enough.
- On open ventilated motors, screens and louvers over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air movement.
- Totally enclosed air to air cooled and totally enclosed fan cooled motors require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up not removed can lead to unbalance and vibration. All of the tubes of the air-to-air heat exchanger should be cleaned using a suitable tube brush having synthetic fiber bristles (not wire of any type).

CLASS II (GE INTERNAL NON-CRITICAL)

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

Revision : 002

Date : 11/07/2017

Page : 24/54



6.3 STANDARD FUNCTION TESTS

6.3.1 Brief Test Descriptions

Insulation Resistance & Polarization Index - a basic characteristic of all insulating materials and has been recognized for many years as one measure of a system's reliability. Factors affecting insulation resistance are contamination, moisture, dust, dirt, oxidation and material degradation due to mechanical and/or electrical factors.

Winding Resistance - recorded to provide current winding resistance, which can be compared to prior tests for trending purposes.

RTD Resistance - performed to ensure the Resistance Temperature Detectors (RTD's) are functioning properly in all slots.

PDA Test (Off Line) - utilizes existing PDA Couplers to record current partial discharge results of the winding. Results can be compared to prior test results for trending purposes.

Dissipation Factor / Power Factor (Doble) Test (Off Line) - results can be compared to prior tests to indicate insulation condition changes. These changes can be caused by factors such as contamination or insulation degradation.

Stator Core Loop Test - to determine and identify stator core iron issues when simulating rated flux density.

Stator Core EL CID Test - a low power alternative to the Stator Core Loop Test. It avoids the testing problems of set-up and safety usually associated with the high excitation of the Stator Core Loop Test, yet provides an accurate indication of lamination damage.

AC or DC Hipot Testing - typically performed at "Suitability for Service" levels (or unit voltage $\times 1.25 = \text{kVAC}$ test voltage) to ensure the integrity of the insulation system. Test levels and plan will be reviewed with customer prior to performing actual test.

DC Leakage / Absorption Test - performed to ensure the integrity of the stator insulation system. A series of high voltage insulation resistance measurements taken at increasing steps of test voltage on a scheduled time basis. Test data is very useful for trending purposes to highlight potential insulation degradation.

Rotor AC Drop Voltage Test - to identify shorted turns in rotor poles. Performed by applying an AC voltage across the entire field pole circuit and measuring the voltage drop on individual poles.

Wedge Tightness - the purpose of the stator wedge is to retain the coil/bar into the slot with the proper tightness, while also preventing movement in the slot. Inspection will confirm if there are hollow or loose wedges, and may result in the need to perform a complete or partial rewedge of the stator.

Borescope Inspection of Vent Slots - to detect contamination, blockage, as well as corona armor damage. Extra attention is focused on the high voltage portion of the winding.

Borescope Inspection of Rotor Poles - to detect loose or broken connections, coil damage, ground and turn insulation movement and/or cracking.

Stator Roundness / Air Gap Checks - to identify conditions that may be outside acceptance criteria for normal operating conditions.



6.3.2 Motor Running Tests (Online)

Wires and cables with damaged insulation are dangerous when carrying electricity. They can also intermittently short, causing equipment and functional failure.

To check wires and cables

1. Check all wires and cables for fraying, chipping, nicks, wear, or rodent damage.
2. Check all wires and cables for signs of overheating or carbonization.
3. Repair minor low-voltage insulation damage with a good grade of electrical tape. If a damaged cable carries high voltages, replace the cable.
4. Replace any cables or wires that have excessive damage.

GE performs on-line monitoring of power circuits to determine the health of a motor. Our motor circuit-testing instrument is low voltage, battery operated, highly portable and capable of full remote monitoring from the Motor Control Centre. Data is collected, stored, trended and recalled to provide you with comprehensive reports.

Stator electrical test	:	10 min Insulation Resistance, Polarization Index, Winding Copper Resistance test, Winding RTD and IR test, Air RTD and IR test, Bearing RTDs test, Stator per phase, Stator phase balance test, Main heater check.
Field electrical test	:	10 min Insulation Resistance, Polarization Index, Winding Copper Resistance test, RTD resistance check and Insulation resistance test,
Other electrical tests	:	Phase rotation, shaft voltage test, shaft discharge resistor, voltage balance or phase balance test,

6.3.3 Motor Static Test (Off-line)

Off-Line motor circuit testing provides you with consistent testing in a safe, simple and cost-effective manner. It also is in a single box with a temperature recorder, DLRO, Megger, DC Hi-pot set and surge tester. Additional pieces of equipment to perform this type of testing are no longer required.

- | | |
|--|-----------------------|
| 1. Visual checks (mechanical & Electrical) | 2. Winding Insulation |
| 3. Voltage Drop Test | 4. Final IR and HV |
| 5. Bearing Insulation | 6. Cold resistances |
| 7. End float and Magnetic centre | |

6.4 MOTOR MONITORING & DIAGNOSIS

- a. Temperature Measurement (Air, Machine, Winding and Bearing)
- b. Vibration (motor frame, bearing housing)
- c. Noise level
- d. Step voltage
- e. Waveform analysis and O.C. Oscillogram at rated voltage



7. ENHANCED TECHNICAL SUPPORT

7.1 MOTOR CIRCUIT TESTING

GE performs on-line monitoring of power circuits to determine the health of a motor. Our motor circuit testing instrument is low voltage, battery operated, highly portable and capable of full remote monitoring from the Motor Control Center. Data is collected, stored, trended and recalled to provide you with comprehensive reports.

On-line Motor Circuit Testing

GE provides on-line monitoring testing services including:

- Power condition tests - voltage level, un-balance, total harmonic distortion
- Motor performance tests - service factor, power factor, motor current, motor speed
- Motor efficiency studies
- Load condition test - load torque, torque ripple and profile
- Motor condition test - rotor bar test
- Trending - tracks all data over time
- Installation of a EP-1 Option, which is a port installed on the outer door of the MCC.

Off-Line Motor Circuit Testing

Off-Line motor circuit testing provides you with consistent testing in a safe, simple and cost-effective manner. It also is in a single box with a temperature recorder, DLRO, Megger, DC Hi-pot set and surge tester. Additional pieces of equipment to perform this type of testing are no longer required. This testing offers the following advantages:

- Current testing technology
- Winding Condition - lead-to-lead resistance
- Winding Insulation Condition - resistance to ground (megger), insulation integrity (polarization index), insulation strength (hipot)
- Turn-to-Turn Condition - detects potential turn-to-turn short before it causes costly winding failure.
- Non-destructive testing

7.2 ADVANCED TESTING, MONITORING & DIAGNOSIS SOLUTIONS

In addition to those standard checks, GE Field Service Engineer shall conduct the following additional function tests for those machines installed at least a year ago during maintenance, if required.

- Digital Diagnosis Management Solutions
- Vibration Analysis
- Thermographic Services
- Motor Reliability Program
- Motor performance monitoring with GE's patented Condition Monitoring System
- Remote Monitoring and Diagnosis (RM&D) for Motors
- Cooling circuit test
- Short-circuited coil test
- Bearing Oil Analysis (Electrical & Mechanical)
- Arc flash hazardous analysis



7.2.1 Digital Diagnostic Management Solutions

GE's Digital Diagnostic Management Solutions (DDMS) is a plant maintenance management program that utilizes the latest in predictive, assessment and maintenance technologies. DDMS offers digital diagnostics for condition assessment and correction of electrical apparatus and associated equipment.

Digital data will be collected in the field, synchronized under a unique identification, and transmitted to GE Energy's global database/WAN Network for data analysis, trending and reporting of your critical equipment. This feature also offers our customers comparative trending of all similar equipment in the entire GE network.

DDMS provides condition monitoring by establishing practical evaluation criteria and routine monitoring to confirm equipment condition, detect developing problems, and to determine their nature and severity. The program is also "solution based" and provides solutions and recommendations to equipment exceeding alarm limits.

7.2.2 Vibration Analysis

GE Energy offers a comprehensive condition monitoring program and extensive vibration troubleshooting services for your equipment. Our vibration analysis detects the following:

- Mechanical misalignment
- Excessive clearances
- Bearing defects
- Base and structural issues
- Belt issues
- Mechanical looseness
- Bent shaft/ thermal bows
- Resonance issues
- Gear defects
- Rotor bar issues

7.2.3 Thermography Services

An infrared, or thermographic, inspection should be performed at least once every three years on all switchgear, distribution panels, cable and bus connections, motor control centers and starters, and other critical equipment. Infrared inspections are extremely beneficial in reducing electrical failures by identifying potentially dangerous conditions; such as, loose or dirty connections, overloaded or imbalanced circuits, or improperly installed equipment. By measuring the heat imbalance relative to the environment and to surrounding equipment, abnormal or adverse conditions can be uncovered that if left unattended would worsen to the point of failure.

GE offers infrared services to detect thermally related issues on your power distribution systems. This infrared scanning technology allows our service technicians to scan and store up to 500 images per visit. By utilizing GE's uncooled camera, the speed of scanning and collecting data has increased dramatically. The lightweight camera has voice annotation, which permits 30 seconds of verbal notes per image. Issues detected in our survey include:

- Localized heating
- Electrical overloads



- Corona tracking
- Defective electrical components
- Arcing
- Loose connections
- Dirty connections

Effective infrared surveys require specialized equipment and should be performed only by qualified technicians. Experience and training is required to accurately identify problem conditions and possible causes so that specific recommendations can be made to correct the situation. It is imperative that these recommendations be implemented in a timely manner to benefit from an infrared inspection. Knowing a problem exists does not help avoid an electrical failure unless corrective actions are employed.

7.2.4 Motor Reliability Program

GE Energy, a leader in the motor industry, understands the costs associated with plant downtime. Because motors are a key link in production systems, maximizing the reliability and life-cycle of a motor can have significant financial benefits to plant operators. To help monitor and maintain the performance of your critical motors, GE Energy now offers the Motor Reliability Program.

You can trust trained GE experts to ensure that the correct materials and procedures are applied to provide the reliability, quality, and performance you require.

By offering an outstanding selection of service options from repairs and refurbishment to new units, GE can help you keep your operation "up and running" with experience you can trust.

This unique program combines two valuable services:

- Performance monitoring with GE's patented Condition Forecaster™ system
- Comprehensive maintenance and repair services

The Condition Forecaster system provides advanced notice of probable failures and statistically forecasts the remaining life of a motor. Using this in-depth information, GE Energy can proactively plan repair or replacement timing for critical process equipment, reducing downtime and improving the efficiency of asset management in your organization.

With limited capital investment required, the Motor Reliability Program includes a Condition Forecaster system for each motor specified in the service contract. GE also provides all necessary motor repair services, whether in-shop or on-site, in response to system alerts.

7.2.5 Motor Performance with GE patented Condition Forecaster™ Monitoring System

Condition Forecaster is a unique and easy-to-use monitoring system that analyzes industry historical motor data and predicts not only specific upcoming failures, but also the expected time before the failure occurs.

GE's patented, leading-edge Condition Forecaster technology offers significant advantages over other types of monitoring systems:

- Uses industry-standard monitoring system data collection such as mechanical, electrical, and ambient measurements.



- Analyzes information in conjunction with other historical data compiled by GE (database includes more than 40,000 maintenance activities to reference).
- Estimates motor residual life through multi-parameter regression analysis, Bayesian belief networks, and Weibull reliability curves.
- Takes advantage of the wide variety of continuous monitoring hardware that may already be in use at customer sites or supplied through other sources.

GE can set up Condition Forecaster in a stand-alone format or remotely monitor equipment status for you. The system sends alerts and time-to-failure estimates via phone, e-mail, or pager when components are under stress.

7.2.6 Remote Monitoring & Diagnostics (RM&D) for Motors

GE's comprehensive motor monitoring strategy enhances the ability of industrial customers to reduce downtime and identify motor failure before it happens. Elements of GE's solution include:

- Continuous technical support through the GE Monitoring & Diagnostic Center (M&D)
- GE engineers analyze your motor's condition data to identify potential failures
- Advanced technology products that retrofit easily into existing equipment and provide the highest levels of protection and reliability
- Prompt installation and commissioning services built on GE's years of field engineering experience and OEM product knowledge



GE Monitoring and Diagnostic Centre



Communications and data management method

RM&D is a complete industrial machine-monitoring package that samples voltage, current, temperature and vibration data and transmits the values via a secure, cellular network connection to the GE Energy M&D Center. At the M&D Center, experienced industrial engineers identify and report erratic machine behavior, which allows for preventive maintenance, condition-based service or halting dangerous operation. RM&D also enables customers to analyze motor operating trends through our secure web connection, which displays all condition data in real time.

GE surveys industrial machine health through the remote monitoring of the key process indicators such as Stator voltage, Stator current, Stator temperature, Bearing temperature, Bearing vibration, Calculation of torque, speed and efficiency, and energy usage, Current signature analysis, Harmonics analysis (current and voltage)



RM&D is applicable to all industrial motors that are attached to a control device that outputs data via Modbus; e.g., GE Multilin 369, 469, M60 or various other manufacturers' relays.

GE Energy can provide a complete motor monitoring solution:

- Comprehensive motor condition monitoring
- Text message/email alerts
- 24-hour monitoring support
- 24-hour engineering support
- Warehoused condition data
- Web-based access for customer visualization of data
- Wireless transmission of data

8. REPAIR & REFURBISHMENT WORKS

We offer a complete range of services for motors in our network of service facilities or on-site at your location. This chapter helps the user with parts replacement, as well as to identify and order replacement parts.

Replacement parts may contain static-sensitive components. Therefore, GE ships replacement parts in anti-static bags. When handling electronics, make sure to store them in anti-static bags or boxes and use a grounding strap (per the following Caution criteria).

Troubleshooting should be done at the system component level. The failed system component (least replaceable part) should be removed, returned to GE, and replaced with a known good spare. Do not attempt to repair system components.

Prior to ordering a replacement part for a GE product, the following items should be understood:

- How to accurately identify the part
- If the part is under warranty
- How to place the order

Note: Renewals and spares (or those not under warranty) should be ordered by contacting the nearest GE Sales or Service Office, or an authorized GE Sales Representative.

Data Nameplate

Each exciter line up, cabinet (panel)/case, and core unit has a unique identifying catalog number, also called the part or ML number. The data nameplate provides the ML number, which links the equipment to its requisition, drawings, components, materials, specification item, and shipping documents. The data nameplate is located on the back of the cabinet door.

Evaluating replacement part needs

During production of Power Conversion motors, a list of replacement parts is generally drawn up consistent with the specific features of each machine.

Backed by our extensive experience in design and construction, Power Conversion's motors are able to meet the high-reliability requirements demanded by the operating conditions of our customers, and the applicable standards governing construction of motors.



8.1 MOTOR MAINTENANCE AND REPAIR SERVICES

Another important feature of the Motor Reliability Program is GE's expert motor maintenance and repair services. GE has been providing quality AC and DC electric motor service and repair for more than 50 years through our global network of service centres. We service equipment from many manufacturers and from a wide range of industries, including motors used in special applications.

You can trust trained GE experts to ensure that the correct materials and procedures are applied to provide the reliability, quality, and performance you require.

Our motor services include:

- Test and inspection
- Failure analysis and diagnostics
- Rebuilds and repairs
- Stator rewinds
- Coil manufacturing
- Insulation system upgrades
- Vacuum pressure impregnation (VPI)
- Replacement parts (exchange program)
- New motors
- Equipment management programs
- Engineering support with on-site field engineering available as needed
- Full on-site service capabilities
- Emergency response, 24x7

By offering an outstanding selection of service options from repairs and refurbishment to new units, GE can help you keep your operation "up and running".



9. FAULT FINDING

9.1 FAILURE TO START OR ACCELERATE

1. Check all connections against the circuit diagram see that there are no open circuits and that all terminals and contacts are clean and right.
2. Check supply voltage at all the motor terminals to see if any reduction is taking place due to line drop. If on autotransformer start is being used, select a higher tapping.
3. Ensure that the machine is not overloaded – try to start the motor uncoupled from load.
4. Check that any thermal, over current or over-voltage protection devices have not been tripped, and that they have been set correctly.
5. Check that stator line currents and phase resistance is balanced and that the insulation resistance is correct.
6. Inspect the rotor bars and end rings.
7. In case of SR Motors, check the rotor resistance-circuit and control.
8. If motor crawls at low speed, the motor and load torque speed curves are probably mismatched. (This is only likely to be of concern when starting STAR/DELTA).
9. Load inertia may be too high, thus resulting in a prolonged start-up time – consult GEPC.

9.2 VIBRATION

1. Run the machine unexcited. If excessive vibration occurs, then it may be of mechanical origin. Check the alignment. If work has been done on the machine, check for correct re-assembly, tightness of holding down bolts and presence of dowels.
2. If vibration is not present unexcited, excite the machine to rated voltage on open circuit. If vibration appears, check that the machine air-gaps are all within 10% of one another.
3. If the vibration is not present on no-load, add load until it appears. Assuming that the load is balanced, such load-dependent vibration could arise from conditions in the field windings, and GE Energy Power Conversion, Rotating Machines should be consulted.
4. If vibration occurs after a system fault or accidental mal-synchronization, then movement could have occurred or damage could have been done. Consult GE Energy Power Conversion, Rotating Machines.
5. Check the rotor bars, end rings and other rotating parts for damage.

9.3 MECHANICAL NOISE

Mechanical noise may occur after work has been carried out on the machine. If this happens, shut down at once and check that no tools, nuts and bolts or debris have been left inside, and that the components have been assembled correctly.

If the noise occurs and no work has been done or if work has been carried out and the above check made, check that:

1. Nothing is rubbing on the shaft (e.g. fan baffles or bearing seals) or coupling.
2. The alignment is correct.
3. The bearing oil supply is working.
4. The air gaps are equal.
5. There is no foreign matter in the air gaps. If there is, establish where it came from.

9.4 MAGNETIC NOISE

1. Check that the load currents are balanced and that the three phase resistances are equal.

CLASS II (GE INTERNAL NON-CRITICAL)

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

Revision : 002
Date : 11/07/2017
Page : 33/54



2. Check all connections. Ensure that there are no bad contacts, and that all connections are clean and tight.
3. Measure the air gap for eccentricity.
4. Check the value of the supply voltage at the motor terminals.
5. Check that the stator line currents and phase resistance are balanced and that the insulation resistance is correct.
6. Inspect the rotor bars and endings.

9.5 WINDING OVERHEATING

Check the following points:

1. Is the load normal, with balanced line currents and the expected power factor?
2. Is the cooling system working properly?
Are both fans running?
External air flow normal and not blocked by tarpaulins, polythene sheets or rubbish?

9.6 BEARING OVERHEATING

1. Self-contained bearings
 - a. Is the oil level correct and is the ring rotating?
 - b. Is the ambient temperature around the bearing higher than usual?
 - c. Are the cooling fins on the bearing housing insulated with dust and dirt?
2. Bearings with an external oil supply
 - a. Are the oil flow and temperature normal?

If the rise in bearing temperature follows after work has been done on the machine, check that the bearing has been correctly assembled and that the thrust or location faces are not permanently in contact.

If new grease is supplied and deteriorated grease discharged properly, the motor will run smoothly. When motors cannot run well because of trouble of bearings, tips for diagnosis are (1) Noise from bearings, and (2) Temperature rise of bearings. When the temperature rise exceeds the specified limit, please check and see whether there is anything wrong.

- a) When temperature rise varies during running, consider the following:
- b) The viscosity resistance of newly supplied or discharged grease.
- c) Insufficient grease or deteriorated grease.
- d) Grease in bearing caps or on retainers falls into the bearing and viscosity resistance there increases abruptly.
- e) The variation of load will cause the temperature of motor to go up.

9.7 LEAKAGE OF OIL

3. Self-contained bearings
 - a. Is the bearing overfilled with oil?
4. Bearings with external oil supply
 - a. Is the oil exit pipe flowing freely?
 - b. Is the specified oil flow rate being exceeded?
5. Both kinds of bearing



- a. Windage from the coupling can cause a local depression, adjacent to the DE bearing, which will draw oil out of the bearing. If this is occurring, the coupling guard arrangement may have to be modified.

9.8 BRUSH HEATING

1. Measure and compare line current with that given on motor nameplates.
2. Check whether brushes are not bedding or sticking in holders – carefully re-bed or clean brushes and adjust pressure, check the spring tension.
3. Check grades of brush material – ensure grade recommended by manufacturer is being used.
4. In case sparking of brush is noticed, polish slip ring surface and apply pressure on brush.
5. We however, do not recommend the dismantling of machines by clients themselves during the guarantee period. In case of any trouble the matter should be immediately communicated to GEPC.

9.9 COOLERS

CACA (IC6A1A6)

1. Is the load normal, with balanced line currents and the expected power factor?
2. Is the cooling system working properly?
3. Are both fans running?
4. Is the external air flow normal and not blocked by tarpaulins, polythene sheets or rubbish?

CACW (IC8A1W7)

1. Is the load normal, with balanced line currents and the expected power factor?
2. Is the cooling system working properly?
3. Is the water on and are the flow and temperature levels normal?
4. Is the water outlet flowing freely?
5. Is air trapped in any of the stacks?
6. If there are two stacks in parallel, are they both at the same temperature?



NOTE



Stacks in series will NOT be at the same temperature

Screen Protected, Drip Proof

7. Is the load normal, with balanced line currents and the expected power factor?

Duct-Ventilated Cooling System with or without Filters

8. Is the load normal, with balanced line currents and the expected power factor?
9. Is the cooling system working properly?
10. Is the duct blocked at its remote end?
11. If there are dampers, are the working properly?

Filtered

12. Are filters blocked or in need of cleaning? Lack of filter maintenance can restrict ventilation and cause overheating.



10. RECOMMENDED MAINTENANCE TOOLS

The following check lists should be on hand for the procedures in this document.

10.1 SEFETY EQUIPMENT

- Site-specific/confined space manual
- Personal safety gear (such as safety boots, safety glasses, hard hat, high-voltage gloves, face shield, safety jacket)
- High-voltage ac/dc detector (with an insulated pole of appropriate length)
- Locks and tags, ganger and caution tape
- Protective grounding cables and grounding stick
- Static-charge wrist straps

10.2 TYPICAL MAINTENANCE TOOLS

- High quality tools, including screwdrivers and pliers, designed specifically for working with electrical wiring systems
- Socket set (metric and standard)
- Hex wrench set (metric and standard)
- 1-inch adjustable wrench
- Torque wrench
- Electrical tape
- Fine file
- Clean dry cloth
- Soft-bristles brush (such as paint brush)
- Mild solution of distilled water and laboratory detergent (Axarel® MicroCare 2200 recommended)
- Isopropyl alcohol and citrus based cleaner
- Digital meter
- High-voltage voltmeter
- One megger tester (capable of dc testing from 500 V up to 5 kV)
- Source of dry, low-pressure compressed air
- Vacuum cleaner with non-metallic nozzle and finely woven, high efficiency filter
- Fuse puller
- Replacement components, if required, including fuses, wire and cable.

10.3 MOTOR ALIGNMENT TOOLS

Customer shall contact GE office, to prepare and ready for the motor alignment before preventive maintenance actions take place by GE.



11. MAINTENANCE SCHEDULE

S. No	TASK DESCRIPTION	1 st Level	2 nd Level	3 rd Level	PERSONNEL
REGULAR MAINTENANCE (OR 1ST LEVEL MAINTENANCE TASKS)					
1	Pre-requisites to perform maintenance	✓	✓	✓	CUSTOMER
2	LOTO	✓	✓	✓	GE
3	STANDARD VISUAL INSPECTION	✓	✓	✓	CUSTOMER
4	Visual Checks (Electrical)	✓	✓	✓	GE
5	Visual Checks (Mechanical)	✓	✓	✓	GE
6	Terminal Cubicle Inspection	✓	✓	✓	GE
7	Frame and Stator core physical inspection		✓	✓	GE
8	Rotor and Field physical inspection		✓	✓	GE
9	Bearing Inspection & Re-lubrication	✓	✓	✓	GE
10	Bearing Sealing Inspection	✓	✓	✓	GE
11	Stator Winding Inspection		✓	✓	GE
12	Cooling circuit & Heat Exchanger Inspection		✓	✓	GE
13	STANDARD CLEANING	✓	✓	✓	GE
14	Cleaning the exterior of the motor	✓	✓	✓	GE
15	STANDARD FUNCTION TESTS	✓	✓	✓	GE
16	Stator Insulation Resistance (IR) Tests	✓	✓	✓	GE
17	Rotor Insulation Resistance (IR) Tests	✓	✓	✓	GE
18	Polarization Index (PI)	✓	✓	✓	GE
19	High Voltage (HV) Test	✓	✓	✓	GE
20	Winding Resistance Test		✓	✓	GE
21	Phase Rotation Test		✓	✓	GE
22	Shaft Voltage Test		✓	✓	GE
23	Bearing Lubrication -Oil qty & Pressure check	✓	✓	✓	GE
24	Bearing run		✓	✓	GE
25	Voltage Balance Test		✓	✓	GE
26	Winding Insulation Test		✓	✓	GE
27	Bearing Insulation Test		✓	✓	GE
28	Cold Resistance Test		✓	✓	GE
29	Voltage Drop Test		✓	✓	GE
30	Final IR & HV Test		✓	✓	GE
31	End float and Magnetic Center check		✓	✓	GE

CLASS II (GE INTERNAL NON-CRITICAL)

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

Revision : 002

Date : 11/07/2017

Page : 37/54



32	Temperature measurement	✓	✓	✓	GE
33	Vibration (motor frame, bearing housing)		✓	✓	GE
34	Noise Level		✓	✓	GE
35	Step Voltage Test		✓	✓	GE
36	Waveform Analysis		✓	✓	GE
ENHANCED TECHNICAL SUPPORT FOR 2ND AND 3RD LEVEL MAINTENANCE TASKS					
37	Motor Circuit Testing			✓	GE
38	Turn-to-turn Test			✓	GE
39	Air-gap Test			✓	GE
40	Bearing Oil Analysis (Mechanical & Electrical)			✓	GE
41	Cooling Circuit Test			✓	GE
42	Temperature Monitoring on Bearings and Windings			✓	GE
43	Stator Winding – Wedge Insulation Tightness Measurements			✓	GE
44	Inter-laminar Insulation test			✓	GE
45	Special Measures related to Motors installed in Explosion Hazard Areas			✓	GE
46	Arc Flash Hazard Analysis			✓	GE
GE SPECIALIZED MAINTENANCE SERVICES FOR 2ND AND 3RD LEVEL MAINTENANCE TASKS					
47	ADVANCED CLEANING			✓	GE
48	Cleaning of windings and Interior of the motor			✓	GE
49	Cleaning of windings with Solvents			✓	GE
50	Cleaning of windings with Detergent Water			✓	GE
51	Cleaning of Brush Gear and Slip-rings			✓	GE
52	MAINTENANCE OF BEARINGS			✓	GE
53	Maintenance of Anti-friction Bearings			✓	GE
54	Maintenance of Sleeve Bearings			✓	GE
55	BOLTED CONNECTIONS TIGHTNESS SOLUTION			✓	GE
56	Check for shaft alignment			✓	GE
57	Compensation of thermal expansion during alignment			✓	GE
58	Tightening of machine mounting screws			✓	GE
59	Systematic check of machine alignment			✓	GE
60	Pinning of the motor			✓	GE
61	Barring speeds (In case of low speed motors)			✓	GE



62	Cooling system alignment check (for motors equipped with air cooler)			✓	GE
63	Connection of bushed bearings lubricated by force-feed lubrication			✓	GE
64	Connections of the cooling circuit			✓	GE
65	High Voltage Connection Tightness Check			✓	GE
ADVANCED TESTING, MONITORING & DIAGNOSIS SOLUTION FOR 2ND AND 3RD LEVEL MAINTENANCE TASKS					
66	GE patented Digital Diagnostic Management Solutions (DDMS)			✓	GE
67	Vibration Analysis			✓	GE
68	Thermography Services			✓	GE
69	Motor Reliability Program			✓	GE
70	Motor Performance Monitoring with GE's patented Condition Forecaster™ Monitoring System			✓	GE
71	Remote Monitoring & Diagnostics (RM&D)			✓	GE
REPAIR or REFURBISHMENT WORKS (if any)					
72	Motor Maintenance and Repair Services			✓	GE
73	DC Motor Repair Services			✓	GE
74	Maintenance of Brush and Commutator (for DC motor only)			✓	GE
75	Maintenance of Slip-rings			✓	GE
76	Laser Alignment			✓	GE
77	Rotor Balancing			✓	GE
78	Maintenance of non-reverse ratchet mechanism (for vertical motors only)			✓	GE
79					
80					

Table.4: Preventive Maintenance Schedule for Motors



12. GLOSSARY OF TERMS

LOTO	- Lock Out Tag Out
IR	- Insulation Resistance
PI	- Polarization Index
ac	- Alternating Current
dc	- Direct Current
CACA	- Closed Air Circuit, Air cooled
CACW	- Closed Air Circuit, Water cooled
DE	- Drive End
NDE	- Non Drive End
ETD	- Embedded Temperature Detector
GA	- General Arrangement
IC	- International Cooling Code
IP	- International Protection Code
IR	- Insulation Resistance
PI	- Polarisation Index
PMG	- Permanent Magnet Generator
R1	- Resistance after 1 minute
R10	- Resistance after 10 minutes
RTD	- Resistance Temperature Detector
RTE	- Rotor Telemetry Equipment
VT	- Voltage Transformer
CT	- Current Transformer
RPM	- Revolutions Per Minute



13. APPENDIX A

GE Energy
Power Conversion

13.1 MAINTENANCE REPORT

1. Customer name : _____
2. Job name : _____
3. Order number : _____
4. Maintenance carried by : _____
5. Department : _____
6. Maintenance start date : _____
7. Maintenance End date : _____
8. Site in-charge / Reporter : _____

S.No	TASK DESCRIPTION	COMMENTS (Include actions completed, observations and any follow-on recommendations)	INITIALS	DATE DD/MM/YY
REGULAR MAINTENANCE (OR 1ST LEVEL MAINTENANCE TASKS)				
1	Pre-requisites to perform maintenance Prior to service start-up, discuss with customer any existing/previous issues with the motor The goal is to determine: What kind of maintenance is required? What maintenance personnel and skill level are needed What sub-assemblies or parts are needed to complete the maintenance What kind of scheduling or coordination with other departments is needed What kind of safety hazards exists with the maintenance? What caused other than the motor breakdown?			

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 41/54



2	LOTO Before any work commences, obtain and review the commissioning site Lock out Tag out (LOTO) procedure. Do not continue until the LOTO procedure has been obtained and deemed satisfactory			
3	STANDARD VISUAL INSPECTION Prior to start up the Maintenance; discuss with the customer any existing/previous issues with the motor. Perform Mechanical disassembly of the following: Electrical disconnection of main stator & excitation stator Disconnection of bearing instrumentation & pipe work Removal of bearing covers, shells & seals Disconnect the rotor earth fault (REFM) (if fitted)			
4	Visual Checks (Mechanical) Inspection should look for: Evidence of damage caused by dirt, loose parts, or foreign objects. Verification that air inlets are not blocked Evidence of moisture and/or dirt build-up Unusual noises, leaking oil seals, or high vibration Oil level gages (if present) should be checked Evidence of degradation of foundation, bed plates, anchor bolts Evidence of oil rings turning (if applicable) Evidence of leaking oil and water piping and connections			
5	Visual Checks (Electrical) Insulation damage, soft or degraded insulation Short circuit damage over the coil or windings exposed partial discharge activity			
6	Terminal Cubicle Inspection Check Line/Neutral Side Cubicles. Clean out and check tightness of the links (if not taped) Check neutral earthing resistor/transformer. Clean out and check tightness of the links (if not taped) Functional checks on cubicle heaters (if fitted)			

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 42/54



7	Frame and Stator core physical inspection Check the paintwork for damage and recommend course of action Inspect enclosure for contaminants ingress (water, dust...) Check mechanical guards - Coupling/shaft protection (If fitted) Inside frame contamination (oil ingress, fallen parts, debris...) Borescope Inspection of other accessible areas (stator and rotor internals) For any coil movement, plugged vent holes, coil bracing adequate and intact, lamination damage, tightness of wedges, etc. Stator core: Check and clean the stator core within reach			
8	Rotor and Field physical inspection Check and clean all reachable rotor components Check all rotor components out of hands reach Check and clean rotating excitation equipment (all components fitted) Check the rotor mounted suppression resistors Check rotor shaft grounding brush & brush older Rotor earth fault (REFM) components check (If fitted) Visually inspect rotor mounted fans balance weights properly secured signs of bar movement signs of rotor/stator rub or lamination damage cooling ducts clear rubbing marks on shaft keyway distortion			
9	Bearing Inspection & Re-lubrication Note the bearing oil flow, vibration and temperature levels (if motor is found running and sensors are operative) Visual inspection of bearing housing, pipework and related hardware Check bearing oil inspection glass Check tightness of oil flange bolts Bearing RTD resistance check and insulation resistance test Inspect oil filters and check operation of filter blockage sensor (If fitted) Check jacking oil lift and record data. (If fitted) Check bearings insulation			
10	Bearing Sealing Inspection Visual inspection of bearings journal and seals Check bearing seal clearances			

CLASS II (GE INTERNAL NON-CRITICAL)

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

Revision : 002

Date : 11/07/2017

Page : 43/54



11	Stator Winding Inspection The following electrical tests shall be conducted in the stator as well as in the exciter windings. 10-minute insulation resistance with polarization index Winding copper resistance Winding RTD resistance check and insulation resistance test Air RTD resistance check and insulation resistance test Stator space heater function checks Check whole rectifier plate for continuity and break insulation Individual checks on diodes (not included, except when a problem has been detected)			
12	Cooling circuit & Heat Exchanger Inspection Check motor air inlet filters (if fitted) Check motor air inlet pressure switch (if fitted and accessible) Check general status and operation of cooling air fan motors Visual inspection of heat exchangers Check for excessive vibration. Check the bearing temperatures and oil levels. If the bearings are supplied with oil from the prime mover system, check the oil flow. Check the winding temperatures Check for oil leaks from bearings, seals, sight-glasses and pipework.			
13	STANDARD CLEANING All parts should be cleaned and baked dry to remove all dirt and contamination. To remove dust from components, clean the stand-off insulators with a clean, dry cloth. Do not use any solvents. Using a fine-filtered vacuum cleaner with a non-metallic nozzle, remove dust and dirt from wiring and electrical components. Inspect cabinet air filters, if equipped. Shake or vacuum filters clean, or replace, as required. After cleaning, examine the parts for pitting or other signs of metal deposits on insulation or insulated parts. If parts are pitted, do not reuse.			
14	Cleaning the exterior of the motor Wear gloves and eye protection when using cleaning fluids and use them only in a well-ventilated area. Normal household cleaners may leave a salt residue behind and must not be used			

CLASS II (GE INTERNAL NON-CRITICAL)

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

Revision : 002

Date : 11/07/2017

Page : 44/54



15	STANDARD FUNCTION TESTS																				
16	Insulation Resistance (IR) Tests on Stator Perform IR check between motor leads and ground. This determines condition of the ground insulation. Record, temperature correct and trend <table><tr><td>Motor voltage</td><td>Test voltage (VDC)</td><td>Acceptable reading</td></tr><tr><td>< 1000</td><td>500</td><td>> 5 megohm</td></tr><tr><td>1000 – 2500</td><td>1000</td><td>> 100 megohm</td></tr><tr><td>2501 – 5000</td><td>2500</td><td>> 100 megohm</td></tr><tr><td>>50000</td><td>5000</td><td>> 100 megohm</td></tr></table>			Motor voltage	Test voltage (VDC)	Acceptable reading	< 1000	500	> 5 megohm	1000 – 2500	1000	> 100 megohm	2501 – 5000	2500	> 100 megohm	>50000	5000	> 100 megohm			
Motor voltage	Test voltage (VDC)	Acceptable reading																			
< 1000	500	> 5 megohm																			
1000 – 2500	1000	> 100 megohm																			
2501 – 5000	2500	> 100 megohm																			
>50000	5000	> 100 megohm																			
17	Insulation Resistance (IR) Tests on Rotor A 500V tester to be used, and the tester earth lead fixed to the rotor body. Make sure that all diodes are temporarily short circuited to avoid damaging them, and make sure that the short circuits are removed when testing is complete.																				
18	Polarization Index (PI) Ratio of the 10 minute IR to the 1 minute IR. (10 min IR / 1 min IR) Determines condition of ground insulation Test voltages similar to the IR test voltages Acceptance criteria ratio > 2																				
19	High Voltage (HV) Test Megger readings must be taken before High Potential Tests. The test voltage must be of approximately sine wave form and during the application of the test the peak value as determined by a Peak reading voltmeter shall be not more than 1.45 times the R.M.S. Value.																				
20	Winding Resistance Test A comparison of the line to line resistances of the motor's winding. This test should be done at the motor terminals using a meter capable of measuring low resistance (milliohms). A typical ohm meter does not have adequate accuracy. Record, temperate correct and trend. Each phase should be within +/- (3% - 5%) of the average of all three phases																				

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 45/54



21	Phase Rotation Test The correct rotation of the machine must first be checked in accordance with the outline drawing			
22	Shaft Voltage Test The volts are to be measured by Avometer and recorded.			
23	Bearing Lubrication (Oil qty & Pressure) check Ensure that all excess oil is cleaned off pedestals, shafts and baseplate; this is to enable any leaks to be detected later, as well as to promote greater safety			
24	Bearing run Shaft vibration with respect to bearing housing should be checked, using GE PC test probes			
25	Voltage Balance Test A clamp-on ammeter to be used to take readings in each phase of a motor in actual operation under normal load. A Tachometer to be used to check the speed of a motor.			
26	Winding Insulation Test The minimum insulation resistance to ground is 1 megohm per kv of rating plus 1 megohm at 40 degrees Celsius ambient.			
27	Voltage Drop Test "Acceptable" for most circuits is less than 0.4 volts, although 0.1 volts or less is preferred. Some starter circuits can allow up to 0.6 volts during a voltage drop test.			
28	Bearing Insulation Test Check for Cracks, Distortion, evidence of excessive heating, Oxidized or corrected conductor/stands, Loose connections To Complete similar to other IR (megger) test. Used to verify condition of insulation on a bearing. Test voltage: 500 Vdc Acceptance criteria: 1 megohm			
29	Cold Resistance Test The cold resistance of all windings must be measured and it is most important that this is done before any other test.			

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 46/54



30	Final IR & HV Test Every machine or insulated part must pass an Insulation Resistance Test using an Insulation Tester, (normally referred to as a Megger).			
31	End float and Magnetic Center check End float will normally be measured and marked before the machine is handed to Factory test.			
32	Temperature Measurement			
33	Vibration (motor frame, bearing housing)			
34	Noise Level			
35	Step Voltage Test			
36	Waveform Analysis and OC Oscillogram at rated voltage test			
ENHANCED TECHNICAL SUPPORT FOR 2ND AND 3RD LEVEL MAINTENANCE TASKS				
37	Motor Circuit Testing			
38	Turn-to-turn Test			
39	Air-gap Test			
40	Bearing Oil Analysis (Mechanical & Electrical)			

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 47/54



41	Cooling Circuit Test			
42	Temperature Monitoring on Bearings and Windings			
43	Stator Winding – Wedge Insulation Tightness Measurements			
44	Inter-laminar Insulation test			
45	Special Measures related to Motors installed in Explosion Hazard Areas			
46	Arc Flash Hazard Analysis			
GE SPECIALIZED MAINTENANCE SERVICES FOR 2ND AND 3RD LEVEL MAINTENANCE TASKS				
47	ADVANCED CLEANING			
48	Cleaning of windings and Interior of the motor			
49	Cleaning of windings with Solvents			
50	Cleaning of windings with Detergent Water			
51	Cleaning of Brush Gear and Slip-rings			

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 48/54



52	MAINTENANCE OF BEARINGS			
53	Maintenance of Anti-friction Bearings			
54	Maintenance of Sleeve Bearings			
55	BOLTED CONNECTIONS TIGHTNESS SOLUTION			
56	Check for shaft alignment			
57	Compensation of thermal expansion during alignment			
58	Tightening of machine mounting screws			
59	Systematic check of machine alignment			
60	Pinning of the motor			
61	Barring speeds (In case of low speed motors)			
62	Cooling system alignment check (for motors equipped with air cooler)			

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 49/54



63	Connection of bushed bearings lubricated by force-feed lubrication			
64	Connections of the cooling circuit			
65	High Voltage Connection Tightness Check			
ADVANCED TESTING, MONITORING & DIAGNOSIS SOLUTION FOR 2ND AND 3RD LEVEL MAINTENANCE TASKS				
66	GE patented Digital Diagnostic Management Solutions (DDMS)			
67	Vibration Analysis			
68	Thermography Services			
69	Motor Reliability Program			
70	Motor Performance Monitoring with GE's patented Condition Forecaster™ Monitoring System			
71	Remote Monitoring & Diagnostics (RM&D)			
REPAIR or REFURBISHMENT WORKS (if any)				
72	Motor Maintenance and Repair Services			

Author : Muthukkumaran, S

DocRef :

File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002

Date : 11/07/2017

Page : 50/54



73	DC Motor Repair Services			
74	Maintenance of Brush and Commutator (for DC motor only)			
75	Maintenance of Slip-rings			
76	Laser Alignment			
77	Rotor Balancing Balance process minimizes the out of balance of the rotor. Acceptable levels are based on speed and application of the machine.			
78	Maintenance of non-reverse ratchet mechanism (for vertical motors only)			
79	Inspection and measurements of bearing journals and housing fits Diameters of the fits should be measured and compared to bearing industry standards. Brg journals and housing bores should be visually inspected for finish, pitting, rubbing and corrosion.			
80	Broken Rotor bar Checks Methods to check for cracked rotor bars include visual, audible, hot spot check, growler, magnetic paper, single phase rotation.			

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

©COPYRIGHT 2017 GE ENERGY (USA), LLC AND/OR ITS AFFILIATES. All rights reserved. GE Energy Proprietary Technical Information

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 11/07/2017
Page : 51/54

[illegible]

Date

Date

Page : 52/54



14. GE POWER CONVERSION CONTACT DETAILS

GE has been setting the standard in manufacturing rotating machines for over 125 years. We continue to deliver innovative mechanical power solutions to the world. Motors are designed and manufactured to operate efficiently and reliably in challenging applications and severe environments where reliability and ease of maintenance is critical.

The Power Conversion Service department has been operational since the electrical rotating machines first began to be manufactured in 1904. Power Conversion Service excels in performance and innovation. Our experienced specialist teams travel throughout the world ensuring minimum intervention time, providing our customers with the technical and research resources of a major manufacturer. Our Service department comprises sections for: replacement parts and motors, maintenance and repair, expertise and diagnostics, installation & commissioning.

If any machine failure or problem occurred during normal operation or maintenance work please contact any one of the below GE operated offices

Service Location	Local number	Dialling costs	Language
ANZ	+61 1300 193 189	Local costs / International	English
China	+86 400 021 5605	Local costs / International	Chinese
France	+33 17731 23 23	Local costs / International	French / English
Germany	+49 69 6612 5588	Local costs / International	German / English
India	+91 44 496 80008	Local costs / International	English
MENAT (UAE) (excluding Iran)	+971 2699 4931	Local costs / International	English
UK	+44 1788 56 3800	Local costs / International	English
NAM	+1 844 437 4474		English
Iran	+33 619365696	Local costs / International	English

* Note that you may be charged different rates when calling from a mobile. Toll free numbers are toll free only in certain countries. Please check with your local provider.

Contact via E-Mail:

Please open the >contact us file.

Please fill in all mandatory fields as accurate as possible (if applicable). Save the file as a .pdf then email to: escc.geem@ge.com.

If you are located in Iran, please email to: service.iran@ge.com



15. MODIFICATION RECORD

Revision	Date	Author	Approver	Details
000	2017-03-16	S, Muthukkumaran	Scolfaro, Juliano	Initial Issue
001	2017-05-11	S, Muthukkumaran	Scolfaro, Juliano	General Update
002	2017-07-11	S, Muthukkumaran	Godfrey, Paul	Paul's comments addressed as well as revised as per comments received from the Commissioning Expertise

Author : Muthukkumaran, S
DocRef :
File : Maintenance Schedule Checklist for GE PC Motors.docx

CLASS II (GE INTERNAL NON-CRITICAL)

Revision : 002
Date : 12/06/2018
Page : 54/54