MOTOR MANUAL

Low Voltage Battery Power 3-Phase AC Induction Motors

Operation and Maintenance Manual

1. Scope of Manual

This manual describes the operation and the maintenance of a low voltage 3-phase AC induction motor [LVAC]. To operate, the motor is connected to and controlled by a variable frequency drive [VFD]. The VFD is connected to battery power.

2. Warnings

⚠ **Before installing, operating or performing maintenance on the LVAC motor, please read this instruction carefully and review the motor outline drawing.**

⚠ **LVAC motors must be supplied power by a VFD**

⚠ **The VFD must be designed and configured for each application**.

⚠ **LVAC motors are <u>not</u> intended to operate on batteries or electrical main lines, 50 or 60 hz. Doing so may cause severe and instantaneous damage to the motor, electrical switchgear and other equipment.**

⚠ **All motors have a maximum operating speed of 4000RPM unless specified otherwise in the application documentation and motor outlines. Consult AMD engineering to review higher speed operating conditions.**

3. Glossary of Parts

<u>Stator</u>; the 3-phase stator consists of a stack of electrical grade steel laminations, insulation and magnet wire. Insulation and wire is rated for Class H (180°C). The magnet wire is manufactured per NEMA MW-35. The stator is connected to the VFD power leads thru tin fused copper ring terminal placed over brass studs. Some stators are fitted with an outer covering typically made of rolled steel or extruded aluminum.

<u>Rotor</u>; the rotor is constructed of a stack of electrical grade steel laminations, with die casted aluminum end rings and bars. The casted rotor is heat shrunk onto a high grade steel shaft. The rotor is dynamically balanced for each application per ISO 1940 Grade 2.5.

<u>Bearings</u>; the bearings are deep grooved ball bearings with double contacting seals, permanently lubricated for long life.

<u>Shaft Seal</u>; motors for tractions applications typically have a synthetic rubber seal to protect the motor from oil migration into the motor.

<u>Quadrature Speed Sensor Cartridge</u>; speed and direction are determined with a quadrature hall- effect cartridge sensor.

Quadrature Speed Sensor Bearing; speed and direction are determined with a quadrature hall- effect sensor bearing.

End Heads; the motor end heads are either die cast aluminum, gravity-fed aluminum or ductile iron castings.

Terminal Block; the terminal block is an insulated component where the motor phase leads are connected to the VFD drive power leads.

4. Motor Outline Drawings

Consult the motor outline drawing for details related to mounting the motor in the application, electrical connections, the type of speed and thermal sensor and their connection. The motor name plate must match that on the motor outline.

⚠ Care must be taken when handling the speed sensor and temperature sensor connectors. When handling the pins internal to the connector, the operator must be grounded to eliminate electrostatic discharge [ESD]. Static discharge at the pins may result in a device failure.

5. Electrical Connections

The motor power connection, U, V W, are specified on the outline drawing. Speed and thermal sensor connectors are defined on the motor outline.

⚠ Care must be taken to make sure that the motor / VFD connections are properly matched. With the correct connection, the motor rotation must match the direction on the motor outline.

6. Bearings

It is recommended that any time the motor is disassembled that new bearings are installed; disassembly can cause damage to the bearings. Although the bearings may look and feel in good condition, the bearing race ways could be brinelled / deformed and may exhibit noise and vibration when assembled or the motor could experience premature bearing failure.

When installing new bearings always press against the race that is absorbing the pressure or bearing damage may occur. See figure 1 for proper installation method.

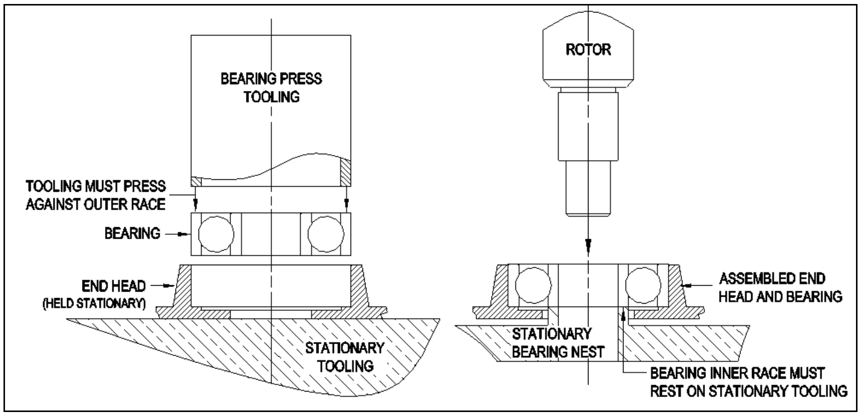

Figure 1: Proper Bearing Installation Method

7. Speed Sensor; Cartridge and Bearing

⚠ Care must be taken when handling the speed sensor connectors; use ESD protection.

The standard LVAC motor is manufactured with a cartridge style quadrature speed sensor. Consult the customer outline to determine the type; i.e. Honeywell SNDH-T4C-G01 or Rheintacho SDN6.FK11.E05R. Both are rated to 150°C, 19,000RPM and IP-68.

⚠ The cartridge sensor's reliable range of operation is limited to a 5-18+VDC supply.

Some LVAC motor designs are equipped with a sensor bearing instead of the cartridge style. Consult the customer outline to determine the type; i.e. SKF, rated to 120°C, 7,500 to 10,000RPM depending on the bearing size.

⚠ The sensor bearing's reliable range of operation is limited to a 4-24+VDC supply.

<u>Cartridge Style Sensor:</u>

RHEINTACHO	SIGNAL	HONEYWELL
Red	+V DC	Yellow
Blue	Channel B	Blue
White	Channel A	White
Black	Ground	Black

Table 1: Speed sensor lead designation.

During service, the functionality of the sensor can be checked. For the inspection, a test box built with LED indicators can be used to test the correct order of the channels. An oscilloscope can also be used. It is very important to assure that the output current doesn't exceed 18mA. An additional resistor with the value below must be connected between each output and supply. The square wave quadrature signals are normally 90±20°, the duty cycle of each output is 50±10%. Frequency of the square wave signals depends on the rotor RPM and number of teeth on encoder wheel. Exact quadrature conditions are design and application dependent; ±45° shift or ±25% duty cycle can occur without problems.

Speed sensors require a pull-up resistor between each channel and +VDC for signal conditioning and reliable operation. These resistors are not supplied as part of the sensor, and are expected to be internal to the connected motor VFD. See table 2.

	RECOMMENDED PULL-UP RESISTOR VALUES			
NOMINAL VFD +VDC SUPPLY VALUE	5V	9V	12V	18V
OHMS BETWEEN YELLOW OR RED AND WHITE OHMS BETWEEN YELLOW OR RED AND BLUE	270Ω	470Ω	680Ω	1000Ω

Table 2: Speed sensor pull-up resistance values.

<u>Bearing Style Sensor:</u>

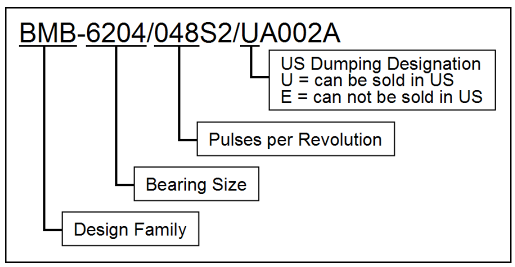

Figure 2: SKF bearing number designations.

SKF	SIGNAL
Red	+V DC
Blue	Channel B
White	Channel A
Black	Ground

Table 3: Speed sensor lead designation.

During service, the functionality of the sensor bearing can be checked. For the inspection, a test box built with LED indicators can be used to test the correct order of the channels. Contact AMD engineering for test box details. An oscilloscope can also be used. It is very important to assure that the output current doesn't exceed 13mA. An additional resistor with the value below must be connected between each output and supply. The square wave quadrature signals are normally 90±30°, the duty cycle of each output is 50±10%. Frequency of the square wave signals depends on the rotor RPM and number of pulses. Exact quadrature conditions are design and application dependent; ±45° shift or ±25% duty cycle can occur without problems.

Sensor bearings require a pull-up resistor between each channel and +VDC for signal conditioning and reliable operation. These resistors are not supplied as part of the sensor, and are expected to be internal to the connected motor VFD. See table 4.

	RECOMMENDED PULL-UP RESISTOR VALUES			
NOMINAL VFD +VDC SUPPLY VALUE	5V	9V	12V	24V
OHMS BETWEEN RED AND WHITE OHMS BETWEEN RED AND BLUE	270Ω	470Ω	680Ω	1500Ω

Table 4: Sensor bearing pull-up resistance values.

8. Thermal Sensor

The LVAC motor is manufactured with a thermal sensor that is imbedded into the stator winding. Consult the customer outline to determine the type. AMD's standard type is Philips KTY84-150.

⚠ Care must be taken when handling the thermal sensor connectors; use ESD protection.

AMD has (2) styles of repair kits.

- For vented motors, a thermal sensor kit that can be mounted to the stator winding thru the vent hole in the end heads is available.
- For non-vented motors, a thermal sensor kit that can be mounted to the outside of the stator or motor housing is available.

PHILIPS KTY84-150	PHILIPS KTY84-130	VISHAY NTCLG100	AMBIENT °C
565-641Ω	577-629Ω	9.5-10.5kΩ	25°C

Table 5: Thermal sensor lead designation and resistance values

9. Tightening Terminal Nuts

Motor terminals must be assembled as shown in Figure 3.

⚠ VFD and motor ring terminals must be assembled back to back; the terminal studs, washers and nuts are for clamping only. The ring terminals are the current carrying members of the connection and must be clamped together with out hardware between them.

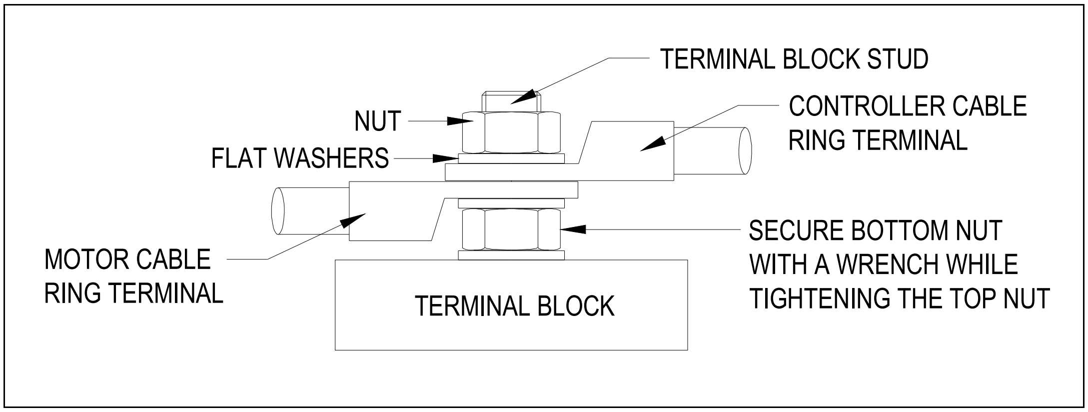

Figure 3: Recommended Terminal Nut Torques Values

Always secure the bottom nut with a wrench when tightening the top nut to avoid loosening the stud or cracking the terminal block. Motor terminals should be tightened to the values shown in Table 4.

TERMINAL SIZE	Torque (in-lb)	Torque (N-m)
M6 or 1/4 in	40-50	4.5-5.6
M8 or 5/16 in	90-110	10.2-12.4
M10 or 3/8in	120-140	13.6-15.8

Table 6: Recommended Terminal Nut Torques Values

10. Service Guidelines

Since the operation environment of LVAC inductions varies widely, the following are suggested for periodic inspection intervals:

Normal Service – Perform routine inspections every 3,000 hours or 2 years. Normal service is defined as 8 hours per day operations, ambient temperature -10°C to 40°C. Ambient conditions must not allow an accumulation of dust, debris or sludge on or in the motor.

Severe Service – Perform routine inspections every 1,500 hours. Severe service is defined as 15 hours or more per day operations or operations in environments such as:

- Dusty or dirty locations like cement plants, mills, mines, food processing plants, etc.
- High temperature areas like steel mills, foundries, etc. or where ambient temperatures are above 40°C or below -10°C.
- Environments with sudden ambient air temperature changes such as in refrigeration warehouses, etc.
- Seaboard environments and environments that regularly see 100% humidity and condensation.

11. Motor Disassembly and Reassembly

⚠ Motors must never be disassembled in the vehicle or with the power leads connected.
⚠ When disassembling the motor, care needs to be taken to avoid damage to the stator winding.
⚠ When assembling the motors, consult the motor outline for the proper bolt torque requirements.

While must LVAC require little maintenance, there may come a time where the motor needs to be repaired. With the variety of LVAC motor constructions, this manual gives generic disassembly guidelines for motors with (2) end heads and (1) end head.

A motor with (2) end heads is a traditional construction and can be operated without additional hardware or fixturing. A motor with (1) end head has to be mounted to a gearbox, transaxle or wheel drive before it can be operated.

Motors with (2) end heads:

1. Remove the speed sensor and encoder wheel.
2. Remove the nuts from each phase lead terminal stud.
3. Remove the screws holding the terminal block to the end head.
4. Determine which end of the motor has the bearing locked in place with a retaining ring; remove the other end head for the stator.
5. Remove the rotor with the other end head.
6. If capable, remove retaining ring from end head and press bearing out of head; press both bearings off of rotor.
7. If retaining ring is not accessible, press bearing off of rotor and repeat for other bearing.

Reverse steps to reassemble motor with new bearings.

Motors with (1) end heads:

1. Remove the speed sensor and encoder wheel.
2. Remove the nuts from each phase lead terminal stud.
3. Remove the screws holding the terminal block to the end head.
4. Remove the rotor with the other end head.
5. Most motors with one end head has the bearing assembled in the head with a retaining ring. If capable, remove retaining ring from end head and press bearing out of head; press both bearings off of rotor.
6. If retaining ring is not accessible, press bearing off of rotor and repeat for other bearing.

Reverse steps to reassemble motor with new bearings.

12. Dielectric Strength Tests

Most of AMD's LVAC motors are built to the UL 583 Electric-Battery-Powered Industrial Trucks standard. This includes all LVAC motors with a terminal voltage up to 72V.

Before a repaired/reconditioned motor is put back into service, it must be dielectrically tested (Hi Pot) per the UL standard; 500VAC between live parts (phase terminal) and motor ground (end heads, stator core) for 1 minute without breakdown. Motors must be clean and dry and repeated test should be avoided.

13. Operational Testing Motor

⚠ LVAC motors are intended to operate with a variable frequency drive/control; operating one on anything but a VFD is dangerous.

A Test Specification is available for each AC motor and is available upon request from AMD. This specification will include unloaded and loaded test conditions.

For motors with (2) end heads:
We recommend that each reassembled motor be tested to the unloaded condition by hooking the phase leads up to a power supply with the voltage and frequency shown in the Motor Test Specification. Use a tachometer to ensure the RPM on the shaft is within the motor specification.

Normally an unloaded motor will run at a speed at or just below an RPM of 120 divided by the pole count times the applied frequency. The standard pole count for LVAC motors is four. So a standard motor operated at 30hz will reach nearly 900RPM uncoupled from a load source.

For motors with (1) end head:
It is impossible to run this type of motor prior to mounting back into its application. We recommend that the motor is mounted back into the application and consult the operations manual of the gearbox, transaxle or wheel drive provider.