PRODUCT DATA SHEET

Vertical A.C. Motors
Open & Enclosed
Holloshaft® & Solidshaft
Varidyne® Inverter Duty

- Weather Protected Type I, Totally Enclosed Fan Cooled and Explosionproof
- High and Normal Thrust Solid Shaft and Holloshaft®
- Premium Efficient Design with Inverter Grade® Insulation System
- Meets NEMA Parts 30 and 31
- Low and Medium Voltage
- 3 through 4000 Horsepower

Product Overview

Significant operational cost savings are possible in many pumping systems with the use of process control. U.S. Electrical Motors' Vertical Inverter Duty Motor is specifically designed for application in process control of variable torque loads through the use of a variable frequency drive (VFD). The evolution of drive technology provides today's user with a reliable, cost effective product. However, this same pulse width modulation (PWM) drive expects the motor will successfully operate in a harsh electrical environment.

U.S. Motors was the first motor company to recognize the need for a special inverter duty insulation system by introducing the first formal Inverter Grade® Insulation System. Our Varidyne® vertical motors offer an insulation system with superior pulse endurance to withstand the stresses produced by the PWM waveform.

It takes more than a pulse resistance magnet wire substitution to become a Varidyne vertical motor. Varidyne vertical motors feature a series of enhancements specifically addressing the reliability concerns arising out of motors operated in tough electrical environments created by VFDs. The Inverter Grade protection system is coupled with a carefully designed mechanical package that provides superior product performance under VFD power. This system meets the stringent requirements outlined in NEMA MG-1, Part 31 (and Part 30).

You can count on U.S. Motors to continue our design efforts aimed at maintaining a compatible product in light of advancing drive technology. We will automatically upgrade our Varidyne® inverter duty product offering as technology advancements become available.

As standard, the Inverter Duty Vertical Motor features premium efficiency, 1.15 service factor, 40° C ambient operation, "P" base, NEMA design B, and low mechanical component stress levels. We recommend our motor with any drive on the market today.

A Look at Inverter Power

Industrial, municipal and agricultural users recognize the need to maximize productivity, reliability and cost savings in light of today's economic climate. System inefficiencies are no longer acceptable.

The application of vertical motors to variable torque pump loads is an ideal candidate for process control through the use of a variable frequency drive (VFD).

Today's VFD products are technically very different from those introduced just a few years ago. Early generations of drives claimed to be compatible with any induction motor. While the claim may have been true, the industry soon found that the use of a Variable Frequency Drive caused thermal problems within the motor. Because the drives adulterated sinewave output and increased the temperature rise in the motors, most applications resulted in early winding failures.

Once the thermal problems were recognized, it became popular to specify a premium efficiency motor for VFD applications. A premium efficiency motor was an easy solution since they were readily available. In addition, they featured a low temperature rise thanks to the additional active materials used to achieve the higher efficiency rating, so they performed better under inverter power than standard efficiency motors. Energy savings through process control and premium efficiency motors provided the optimum payback.

At the time, the use of a premium efficient motor solved the thermal problem in many motor and drive system combinations. While drive technology continued to evolve, many engineers and users became comfortable with this motor solution.

Inverter Grade Insulation System

Recently a shift in drive technology once again has caused an increase in motor failures. Today advances in microprocessors and power semiconductor technology has evolved to improve the performance, reliability and cost attributes of VFD's. This evolution has occurred over a 20 year period. With each power semiconductor milestone achieved, drive switching frequency increased.

Increased switching frequency created new challenges for existing insulation systems. Electric motor insulation systems have, for the most part, not changed in 30 years. Today it is no longer accurate to think that inverter driven motors have only a thermal problem - one which can be solved by using a premium efficient motor. Drives now produce high rate-of-rise voltage waveforms that impose high impulse electrical stress on the motor insulation. Unfortunately, most current insulation life standards do not specify the maximum repetitive voltage transients, the switching frequency (kHz) or the rate of rise that the winding should be able to withstand and still maintain normal life expectations. Standard insulation systems are not designed to operate in this new electrical environment. When they are, unpredictable motor performance is the result.

U.S. Electrical Motors was the first to recognize the need for a special inverter duty insulation system by introducing the our original Inverter Grade® Insulation System. This early system provided protection against the effects of IGBT power devices through the use of additional phase paper end-turn bracing as well as triple film polyester overcoated magnet wire. The benefit was clear that under inverter fed applications a significant improvement in winding life was achieved. However, increased insulation material reduced the copper content, therefore reducing motor efficiencies. The new challenge in engineering design became maintaining or improving the winding integrity under VFD power while *also* regaining lost efficiency.

USEM teamed with Phelps Dodge to develop a new and improved insulation system. The result is the first major advancement in magnet wire technology and motor insulation systems specifically designed and tested for VFD applications. This new pulse resistant (TZ-QS Quantumshield) magnet wire along with U.S. Motors' patented insulation system is at the heart of the current Inverter Grade® product.

You can count on USEM to continue our design efforts aimed at maintaining a compatible product for the advancing drive technology.

Pulse Endurance Test

To validate the Inverter Grade magnet wire, we developed the Pulse Endurance Test. This test has become the standard basis for comparing various types of insulation under VFD power. The result is USEM's Inverter Grade® Insulation System which meets the stringent requirements outlined in NEMA MG-1, 1993, Part 30 and 31.

> **Part 30 = Level 1**
> General Purpose product capable of reliable performance in Inverter installations where peak transients do not exceed 1000V and/ or rise times are not shorter than 2 microseconds.
>
> **Part 31= Level 2**
> Definite purpose product capable of reliable performance in Inverter installations where peak voltages do not exceed 1600V and/ or rise times are not shorter than .1 microsecond.

Motor failures have been random in nature due to uncontrolled transient pulse conditions from the inverters. A magnet wire test device that reproducibly simulates the electrical environment found in inverter-fed motors has been built to study insulation failures through the Pulse Endurance Test.

Inverter Characteristics
Switching Frequency from 1 to 20 kHz
Switching Transient Voltage Rise Times
Transient Voltage 2-3 pu (line to ground)

Test Device Capability
60 Hz to 20 kHz Pulse Frequency
10 to 100 kV/msec Rise Time
1000 to 5000 V Peak to Peak (square wave)

The testing parameters for the Pulse Endurance Test have been determined by examining the actual inverter characteristics and determining the worst case pulse condition that a motor would experience.

Pulse Endurance Test Method
Dielectric twists of 18 AWG wire coated with the test insulation are aged in a forced air oven at 90 degrees C under the electrical stress condition of 0.025 msecond pulse rise time, 2kV peak voltage, 20 kHz pulse frequency, 50% duty cycle square wave. The time to failure of the product is recorded in seconds. The Pulse Endurance Index (PEI) is a ratio of the endurance life of the sample under test in comparison to 18 AWG wire using heavy build MW35 insulation.

Pulse Endurance Index (PEI) = Endurance Life of Test Sample/ Endurance Life of Heavy Build MW35 Sample

Stock & Custom Motors Available
Varidyne® Vertical Motors with our patented Inverter Grade® insulation system are available from stock or conversion. We can customer engineer a product as well to help you take advantage of our extensive modification capabilities.

- Altitude above 3300 ft
- Ambient above 40°C
- Bearing Thermal Protection
- Capacitors
- Current Transformers

- Extra High Thrust
- Space Heaters
- Special Balance
- Surge Protection
- Thermostats
- Thermistors
- Winding RTDs

Varidyne® Vertical Motors - providing you reliable performance under VFD power and greater peace of mind.

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