

Application Information

AGENCY LISTINGS

UL and CSA

Where applicable, Marathon Electric's motors are UL Listed for explosion proof enclosures, UL Recognized construction for non-explosion proof enclosures, and UL Recognized as a motor/protector combination. Our motors are also CSA Certified for both explosion proof and non-explosion proof enclosures.

AC Motors

Non-Explosion Proof	UL File No.	CSA File No.
NEMA 48-449 Frame	E49747	LR2025
NEMA 500 and 5000 Frame	—	LR2025*
IEC 63-90 Frame	E49747	LR2025
IEC 100-280 Frame	E49747	LR2025*
* Does not include coverage for use with VFD		
† Domestic product only		
Explosion Proof	UL File No.	CSA File No.
NEMA 56-326 Frame	E12044	LR47504
NEMA 364-449 Frame	E12044	LR21839
Fire Pump Motors	UL File No.	CSA File No.
NEMA 143-510	EX5190	LR2025

PMDC Motors

Non-Explosion Proof	UL File No.	CSA File No.
NEMA -56-145	E57948	LR33543

CE (Conformity Europeenne)

CE marking on the nameplates of Marathon Electric motors is available upon request. Note that only the "Low Voltage" directive applies to electric motors. Contact a factory representative for details. Non-explosion proof microMAX™, BlackMax® and BlueMax® (TENV and TEFC) standard (catalog) models have the CE Mark on the nameplate.

ATEX Directive (Atmospheres Explosibles)

Mandatory by law, the European Union (EU) Directive 94/9/EC requires that electric motors in contact with a potential ignition source carry the CE mark, notified body identifier, Ex symbol, equipment group and category, plus the date code.

NEMA (National Electrical Manufacturers Ass'n)

All Marathon Electric motors are manufactured in accordance with all applicable NEMA standards in MG1-2003. When applied in accordance with the "Guidelines for Application of Three Phase Motors on Variable Frequency Drives", **Marathon Electric motors are in full compliance with NEMA MG1-2003, Part 31, Section 4.4.2**, as pertaining to voltage spikes. 460 volt motors must withstand voltage spikes of up to 1426 volts; 575 volt motors must withstand spikes up to 1788 volts. See "Insulation Systems" for additional detail on this subject.

Commitment to RoHS and WEEE European Directives

European Directive 2002/95/EC "Restriction of Use of Certain Hazardous Substances" (RoHS) and Directive 2002/96/EC "Directives on Waste Electrical and Electronic Equipment" (WEEE) were enacted to control the amount of certain hazardous substances contained in products shipped into the E.U. Restricted substances include lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated dipheynl ethers.

The scope of products covered, affecting motors, is:

- Large household appliances
- Small household appliances
- IT and telecommunications equipment
- Consumer equipment
- Electrical and electronic tools (except large scale stationary and industrial tools)
- Toys, leisure and sports equipment
- Automatic dispensers

In addition to the exemption above, the Directives do not currently apply to medical devices, monitoring and control instruments, spare parts for the repair or reuse of electrical and electronic equipment placed on the market before July 1, 2006, and most military and state security equipment.

Regal Beloit Corporation worked closely with suppliers to assure that product falling within the scope of these directives meets the specified levels of these substances. The directives took affect July 1st, 2006 however many products were converted in May and June. The products converted are motors in NEMA frame size 145 and below, both AC and DC motors with the following exceptions:

- Sleeve bearing motors **(an exemption has been applied for). A compliant ball bearing equivalent motor can be ordered.**
- Brake motors in 56-145 frame **will have to be ordered specifically as RoHS compliant.**
- **Some motors with specialty electro-mechanical components.**

BEARINGS

FRAME SIZE	STANDARD TYPE	COMMENTS
48	Shield Ball	Sleeve bearing as noted
56 - 145T	Sealed Ball	
182 - 444T	Double Shield Ball	
284 - 449TS	Single Shield Ball	
445T - 6805	Double Shield Ball	Direct - coupled loads
445T - 6805	Roller (DE)/Ball	Belted loads

* **Beltng data must be provided on all belted applications**

Standard horizontal motors can be mounted in a vertical shaft down orientation (except brakemotors). Contact a factory representative for shaft up mounting arrangements.

Marathon Electric motors employ the use of Mobil POLYREX® EM grease, a specially formulated bearing grease designed for electric motors. POLYREX® EM provides superior lubricity, durability and resists corrosion, rust and washout. POLYREX® EM is a registered trademark of Mobil Corporation.

Maximum safe mechanical speed capability is a function of bearing size, type and grease selection, as well as rotor balance specifications. Consult the "Maximum Safe Mechanical Speed Limits" chart in the "Overspeed Capability" section.

Note that these values do not imply maximum constant horsepower RPM.

EFFICIENCY

The efficiency of a motor is the ratio of its useful power output to its total power input and is usually expressed in a percentage. Marathon Electric offers standard, high efficient EPA, and premium efficient (XRI®) ratings. Standard efficiency motors may only be used on applications that are exempt from EPA. The high efficient motor line is in compliance with the Energy Policy Act of 1992 (EPA) and/or Canadian efficiencies as set by NRCAN. The XRI® line is a premium efficiency line, which exceeds mandated efficiencies of EPA and /or NRCAN. Unless otherwise noted, XRI® premium efficient motors in this catalog meet NEMA Premium® the newly promoted efficiency levels by NEMA and the Consortium for Energy Efficiency (CEE).

ELECTRICAL TYPE/STARTING METHOD

Motors in this catalog are capacitor start, split phase, permanent split capacitor, or three phase. Capacitor Start motors have high starting torque, high breakdown torque, and relatively low starting current. Split phase motors have medium starting torque and medium starting current. Permanent split capacitor motors have low starting torque and low starting current. Three phase motors have high starting, extra breakdown torque, and typically very low starting current. Single phase motors cannot be applied on variable frequency drives with three phase output.

ENCLOSURE AND METHOD OF COOLING

Marathon Electric motors are available in various enclosures; Dripproof (DP), Dripproof Force Ventilated (DPFV), Totally Enclosed Fan Cooled (TEFC), Totally Enclosed Non-Ventilated (TENV), Totally Enclosed (TEAO) and Totally Enclosed Blower Cooled (TEBC). Application conditions will determine the type of motor enclosure required.

Dripproof motors have open enclosures and are suitable for indoor use and in relatively clean atmospheres. Dripproof motors have ventilating openings constructed so that drops of liquid or solid particles falling on the machine at an angle of not greater than 15 degrees from the vertical cannot enter the machine.

Totally enclosed motors are suitable for use in humid environments or dusty, contaminated atmospheres. Totally enclosed non-ventilated motors are NOT cooled by external means. Totally enclosed fan cooled motors are cooled by external means that are part of the motor but not in the internal workings of the motor. Totally enclosed air over motors are sufficiently cooled by external means, provided by the customer.

HAZARDOUS DUTY™

Hazardous Duty™ motors are totally enclosed (fan cooled or non-ventilated) motors designed for applications in hazardous atmospheres containing explosive gases and/or combustible dusts.

North American installations

North American standards for electric motors generally fall into one of two divisions. Division 1 Explosion Proof motors are UL Listed in accordance with NFPA Class I (Flammable Gases) or Class II (Combustible Dusts) and Groups (gases or dusts), depending upon the atmosphere. Division 2 motors are CSA Certified and are marked similarly to Division 1 equipment. Inverter Duty motors through 449T are CSA Certified for use in Division 2 locations.

European installations

Motors for hazardous locations in Europe must meet a different set of standards and require different markings than those of North America. CENELEC sets the standards for equipment in hazardous locations for Europe. Motors for explosive atmospheres in Europe are often referred to as flameproof or non-sparking motors. These motors must comply with the ATEX Directive. The ATEX Directive covers all electrical equipment used in explosive atmospheres. To ensure compliance with the Directive, equipment must meet the essential ATEX requirements and carry the CE mark on the nameplate. Other information required on the nameplate is the Ex symbol, group & category, date code, EEx, protection method, gas group, and temperature code. (Example: EEx d IIB T4 CE0359 Ex II 2 G/D 2004)

The tables on page 12 describe Marathon Electric's capabilities by Area Classification and by Temperature Code.

IEC DEGREES OF PROTECTION vs. MARATHON ELECTRIC'S STANDARD CONSTRUCTION

The enclosure terminology for an IEC motor is a combination of the IP (Ingress Protection) and IC (Inherent Cooling) codes. Each number in the IP code stands for a different degree of protection.

- IP12 - Dripproof
- IP22 - Dripproof with screens, or die cast aluminum bracket
- IP43 - Totally Enclosed
- IP54 - Totally Enclosed Severe Duty
- IP55 - Totally Enclosed Severe Duty with V-Ring Shaft seals, and/or "Smart Ring" rotating shaft seal and Neoprene gaskets
- IP56 - Totally Enclosed Severe Duty with rotating Shaft seals (eg. Inpro/Seal VBX bearing isolator) and Neoprene gaskets

Application Information

Marathon Electric Hazardous Duty Motor Area Classification Chart

APPLICATION INFORMATION

Class I Area Classification (Flammable Gases, Vapors or Mists)				Class II Area Classification (Combustible Dusts)			
North America		Europe - ATEX (Category G - Gases)		North America		Europe - ATEX (Category D - Dusts)	
Division 1 Explosion Proof	Division 2 TEFC & TENV	Zone 1 Flameproof	Zone 2 Non-Sparking	Division 1 Explosion Proof	Division 2	Zone 21 Flameproof	Zone 22 Non-Sparking
Group A ^①	Group A	Group IIC, Category G ^①	Group IIC, Category G	-	-	-	-
Group B ^①	Group B	Group IIC, Category G ^①	Group IIC, Category G	-	-	-	-
Group C	Group C	Group IIB, Category G	Group IIB, Category G	-	-	-	-
Group D	Group D	Group IIA, Category G	Group IIA, Category G	-	-	-	-
-	-	-	-	Group E ^①	-	-	-
-	-	-	-	Group F	Group F ^①	Category D	-
-	-	-	-	Group G	Group G ^①	Category D	-

- Group is not applicable to that Division or Zone, or is not defined.
- ① Group is not available from Marathon Electric.

Marathon Electric Hazardous Duty Motor Temperature Code Chart

	TEMPERATURE CODES		Division 1 Explosion Proof/Zone 1 Flameproof		Division 2/Zone 2 Non-Sparking
			Class I Area Classification (Flammable Gases, Vapors or Mists)	Class II Area Classification* (Combustible Dusts)	Class I Area Classification (Flammable Gases, Vapors or Mists)
Temp.	UL/CSA	ATEX	Division 1/Zone 1	Division 1/Zone 21	Division 2/Zone 2
280°C	T2A	T2(280)	Explosion Proof - Class I, Group D (Group C as noted)		
260°C	T2B	T2(260)			XRI® Severe Duty & IEEE-841 @ 1.15 S.F., Class I, Groups A,B,C,D (Sine wave power)
215°C	T2D	T2(215)			Available through Marathon's Mod Central on Totally Enclosed EPAct, XRI®, XRI® Severe Duty or IEEE-841 @ 1.0 S.F. on PWM VFD, Class I, Groups A, B, C, D
200°C	T3	T3			Available through Marathon's Mod Central on Totally Enclosed EPAct, XRI®, XRI® Severe Duty or IEEE-841 @ 1.0 S.F., Sine wave power Class I, Groups A, B, C, D
165°C	T3B	T3(165)	Explosion Proof - Class I, Group D (Group C as noted), Sine wave or PWM power	Explosion Proof - Class II, Groups F & G, Sine wave or PWM power	
160°C	T3C	T3(160)	Available through Marathon's Mod Central on Explosion Proof - Class I, Group C & D @ 1.0 S.F. - Contact Factory	Available through Marathon's Mod Central on Explosion Proof - Class II, Group F & G @ 1.0 S.F. - Contact Factory	
135°C	T4	T4	ATEX compliant motors	ATEX compliant motors	

* Class II, Division 2 motors are not available from Marathon Electric, Zone 22 groups are not defined by ATEX.

INSULATION SYSTEMS

Class B – General Purpose motors that employ Class B insulation systems have a total temperature rating of 130°C and maximum allowable temperature rise of 80°C at 1.0 S.F.

Class F – Motors with a Class F system have a total temperature rating of 155°C, with a maximum temperature rise of 105°C at 1.0 S.F. Many Marathon Electric designs utilize a Class F system but limit temperature rise to no higher than "B" rise, providing thermal "headroom" for longer insulation life.

Class H – Class H insulated motors have a total temperature rating of 180°C and maximum allowable temperature rise of 125°C. All Marathon Electric motors that employ a Class H system are designed to operate between "B" and "F" rise, giving the user a generous thermal cushion.

"CR²⁰⁰" – Corona Resistant, 200° rated magnet wire is utilized in numerous general purpose and inverter duty motor designs to extend insulation life under the rigors of steep fronted voltage spikes, common with today's IGBT inverters. Refer to page 14 for product lines that employ the use of CR²⁰⁰ magnet wire.

Motors with the CR²⁰⁰ insulation system can be operated at up to 475 feet from the drive on 460 volt systems, at 3 KHz carrier frequency. For other voltages and/or carrier frequency combinations, contact a factory representative.

MAX GUARD® – All Black Max®, Blue Max®, Blue Chip®, XRI® Severe Duty and XRI®-841 (IEEE841) motors feature the MAX GUARD® insulation system, either in conjunction with Class F or Class H materials. Combining corona-resistant magnet wire (CR²⁰⁰) with our patented "low stress" winding configuration and uncompromising quality standards, MAX GUARD® delivers long, dependable motor life under the adverse thermal and dielectric stresses imposed by IGBT-based variable frequency drives. **MAX GUARD® surpasses the requirements of NEMA MG1-2003, Part 31, Section 4.4.2.**

460 Volt (or lower) motors equipped with MAX GUARD® can be operated at any distance from the drive and at any carrier frequency. 575 Volt motors can be operated at up to 650 feet cable length at 3 KHz.

MOUNTING

Most Marathon Electric motors are designed for horizontal mounting (shaft parallel with ground), unless designed otherwise, such as Vertical P Base motors. As a general rule, a horizontal motor can also be mounted in a vertical shaft down orientation. Horizontal motors should never be mounted in a vertical shaft up orientation without consulting your application engineer, as this practice can cause damage to the motor, which is not covered under warranty. Brakemotors should not be mounted vertically (up or down), unless the brake has been specifically designed for such.

NEMA SERVICE FACTOR RATINGS

The table below lists the NEMA service factors for single phase, dripproof motors. Totally enclosed and explosion proof motors have 1.0 service factor except where noted.

Single Phase

NEMA SERVICE FACTOR @ RPM LISTED

HP	3600	1800	1200	900
1/12	1.4	1.4	1.4	1.4
1/8	1.4	1.4	1.4	1.4
1/6	1.35	1.35	1.35	1.35
1/4	1.35	1.35	1.35	1.35
1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1.5 & Up	1.15	1.15	1.15	1.15

OVERLOAD PROTECTION

There are four choices in protection: manual (inherent type), automatic (inherent type), thermostats, and none. A manual overload must be physically reset to restart the motor. An automatic thermal overload will stop the motor when it is overloaded or overheated and restart it after the motor has cooled down. None means the motor has no protection. Thermostats are embedded in the winding and connected to the motor starter control circuit. Marathon Electric's standards are normally closed thermostats, one per phase.



A motor with an automatic reset protector must not be used where automatic restarting (after motor cool-down) would endanger personnel or equipment. Such applications should use a manual reset protector.

PHASE/POWER SUPPLY

Is the power supply three phase or single phase? Most home and farm applications require single phase motors. While most factories, large commercial and industrial users require three phase motors. Single phase motors can be used on three phase systems. Three phase motors, however, cannot be operated from single phase systems. Motor damage will result.

ROTATION

Most motors in this catalog are reversible by electrical reconnection or by physical orientation. Marathon Electric's standard rotation from the factory for single phase motors is counterclockwise, when viewing the opposite shaft end of the motor

SPEED/RPM

3600, 1800, and 1200 are the most common 60 HZ synchronous speeds with full load speed equivalents of 3450, 1725, and 1150.

Application Information

TERMINOLOGY

Ambient Temperature – Temperature of the medium, such as air, water or earth, into which the heat of the equipment is dissipated.

Ampere (AMP) - A measure of the rate of current through the motor.

Base Speed – Nameplate rating where the motor will develop rated HP at rated load and voltage. With AC systems, it is commonly the point where 60 Hz is applied to the induction motor.

Breakaway Torque – The torque required to start a machine from standstill.

Breakdown Torque (BDT) – The maximum torque that an AC motor will develop with rated voltage applied at rated frequency while rotating.

Cogging – A condition in which a motor does not rotate smoothly but "steps" or "jerks" from one position to another during shaft revolution. Cogging is most pronounced at low motor speeds and can cause objectionable vibrations in the driven machine.

Continuous Duty – The continuous rating is the maximum constant load that can be carried continuously without exceeding established temperature rise limitations under prescribed conditions of load and within the limitations of established standards.

Definite Purpose Motor – Any motor design, listed and offered in standard ratings with standard operating characteristics and mechanical construction, for use under service conditions other than usual or for use on a particular type of application (NEMA).

Duty Cycle – The relationship between the operating and resting times or repeatable operation at different loads and/or speeds.

Efficiency – Ratio of power output to power input indicated as a percentage. In motors, it is the effectiveness with which a motor converts electrical power into mechanical power.

Frequency – Number of cycles per second of alternating current 60HZ used primarily in the United States, 50HZ normally used overseas.

Full Load Torque (FLT) – The torque necessary to produce rated horsepower at full load speed.

General Purpose Motor – This motor has a continuous duty rating and NEMA A or B design, listed and offered in standard ratings with standard operating characteristics and mechanical construction for use under usual service conditions without restriction to a particular application or type of application (NEMA).

Inertia – A measure of a body's resistance to changes in velocity, whether the body is at rest or moving at a constant velocity. The velocity can be either linear or rotational. The moment of inertia (WK^2) is the product of the weight (W) of an object and the square of the radius of gyration (K^2). The radius of gyration is a measure of how the mass of the object is distributed about the axis of rotation. WK^2 is usually expressed in units of lb-ft².

Intermittent Duty – A motor that never reaches equilibrium temperature, but is permitted to cool down (to ambient temperature) between operations. For example, a crane, hoist or machine tool motor is often rated for 15, 30 or 60 minute duty.

Load Sharing – An application condition in which two or more similar-sized AC Induction motors are mechanically connected to each other and powered from the same inverter. Optimum load sharing is achieved with higher slip (NEMA Design B or C) motors.

Locked Rotor Current (LRA) – Steady state current taken from the line with the rotor at standstill, at rated voltage and frequency. This is the current when starting the motor and load across the line.

Locked Rotor Torque (LRT) – The minimum torque that a motor will develop at rest for all angular positions of the rotor, with rated voltage applied at rated frequency.

No Load (Conditions) – The state of a machine rotating at normal speed under rated conditions, but when no output is required from it.

Power Factor – Power factor is the ratio of real power (kW) to total kVA, or the ratio of actual power (W) to apparent power (volt-amperes).

Reactance – The opposition to the flow of current made by an induction coil or a capacitor. Performance data expresses stator reactance as X1 and rotor reactance as X2.

Resistance – The opposition to voltage or current in an electrical circuit. Performance data expresses stator resistance as R1 and rotor resistance as R2.

Rotor – The rotating member of a machine with a shaft.

Service Factor (SF) – When used on a motor nameplate, a number which indicates how much above the nameplate rating a motor can be loaded intermittently without causing serious degradation (i.e. a motor with 1.15 SF can produce 15% greater torque than one with 1.0 SF, within temperature constraints).

TERMINOLOGY

Shock Load – The load seen by a clutch, brake or motor in a system that transmits high peak loads. This type of load is present in crushers, separators, grinders, conveyors, winches and cranes.

Slip – The difference between the speed of the rotating magnetic field (synchronous speed) and mechanical rotational speed (rotor speed) of AC induction motors. Usually expressed as a percentage of synchronous speed.

Special Purpose Motor – A motor with special operating characteristics, special mechanical construction, or both, designed for a particular application and not falling within the definition of a general purpose or definite purpose motor (NEMA).

Speed Range – The minimum and maximum speeds at which a motor must operate under constant or variable torque load conditions. A 50:1 speed range for a motor with top speed of 1800 RPM means the motor must operate as low as 36 RPM and still operate within specifications.

Starting Torque – The torque exerted by the motor during the starting period.

Stator – The stationary portion of the magnetic circuit and the associated windings and leads of a rotating machine.

Synchronous Speed – The speed of an AC induction motor's rotating magnetic field. It is determined by the frequency applied to the stator and the number of magnetic poles present in each phase of the stator windings. Mathematically, it is expressed as Sync Speed (RPM) = 120 x Applied Frequency (Hz)/Number of Poles per phase.

Torque – A turning force applied to a shaft, tending to cause rotation. Torque is normally measured in "pound-feet" and is equal to the force applied times the radius through which it acts.

Torque-to-Inertia Ratio – The rated motor torque divided by its rotor inertia. Helps determine a motor's ability to accelerate loads and/or respond to commands from a drive to change speed or direction.

FORMULAS & CONVERSION FACTORS

$$\text{Torque (lb-ft)} = \frac{\text{HP} \times 5250}{\text{RPM}}$$

$$\text{HP} = \frac{\text{Torque (lb-ft)} \times \text{RPM}}{5250}$$

$$\text{Synchronous RPM} = \frac{120 \times \text{Frequency}}{\# \text{ Poles}}$$

$$\text{Ohms} = \text{Volts} / \text{Amperes} (R = E/I)$$

$$\text{Amperes} = \text{Volts} / \text{Ohms} (I = E/R)$$

$$\text{Volts} = \text{Amperes} \times \text{Ohms} (E = IR)$$

$$\text{Newton-meters (torque)} = 1.3558 \times \text{lb-ft}$$

$$\text{Pound-feet (torque)} = .7376 \times \text{Newton-meters}$$

$$\text{Horsepower} = 746 \text{ watts} (.746 \text{ KW})$$

$$\text{Kilowatts (KW)} = 1.341 \times \text{Horsepower}$$

$$\text{Temperature (° Celsius)} = 5/9 \times (°\text{F} - 32)$$

$$\text{Temperature (° Fahrenheit)} = (9/5 \times °\text{C}) + 32$$

Variable Speed Operation

Guidelines for Application of General Purpose, Three Phase, Single Speed Motors on Variable Frequency Drives Meets NEMA MG1-2003 Part 30 and Part 31 Section 4.4.2 Unless stated otherwise, motor nameplates do NOT include listed speed range.

ENCLOSURE	EFFICIENCY	VARIABLE TORQUE	CONSTANT TORQUE								
		ALL FRAMES	56	143-215		254-286		324-365		404-449	
NEMA Motors		ALL POLES	ALL POLES	2-Pole	4&6 Pole	2-Pole	4&6 Pole	2-Pole	4&6 Pole	2-Pole	4&6 Pole
ODP	Standard (EPAAct exempt)	10:1	2:1	2:1	2:1	Contact Engineering					
	EPAAct compliant	10:1	N/A	2:1	2:1	2:1	2:1	Contact Engineering			
	NEMA Premium (XRI)	10:1	N/A	10:1	10:1	10:1	10:1	10:1	10:1	2:1	2:1
TEFC	Standard (EPAAct exempt)	10:1	2:1	2:1	2:1	Contact Engineering					
	EPAAct compliant	10:1	N/A	2:1	10:1	2:1	10:1	2:1	2:1	2:1	2:1
	NEMA Premium (XRI)	10:1	N/A	2:1	20:1	2:1	20:1	2:1	20:1 (1)	2:1	20:1 (1)
TENV	EPAAct compliant	10:1	N/A	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1
	NEMA Premium (XRI)	10:1	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1	1000:1
Washdown TEFC	Standard (EPAAct exempt)	10:1	10:1 (2)	10:1 (2)	10:1 (2)	N/A	N/A	N/A	N/A	N/A	N/A
	EPAAct compliant	10:1	N/A	10:1 (2)	10:1 (2)	N/A	N/A	N/A	N/A	N/A	N/A
Washdown TENV	Standard (EPAAct exempt)	10:1	1000:1	1000:1	1000:1	N/A	N/A	N/A	N/A	N/A	N/A
	EPAAct compliant	10:1	N/A	1000:1	1000:1	N/A	N/A	N/A	N/A	N/A	N/A
Explosion Proof	All efficiency levels	Explosion Proof motors must be properly nameplated with inverter duty information prior to use on VFD. See Marathon catalog pages for specific rating capabilities. Motors with automatic overload protectors cannot be used on VFDs.									
IEC Motors		ALL FRAMES	63-90	100-225							
All Enclosures	All efficiency levels	10:1	20:1	Up to 20:1							

Notes: (1) 324-449T, 4 & 6 Pole XRI motors are rated for 20:1 C.T. with fan modification; otherwise rated for 2:1 C.T. continuous duty, or 20:1 C.T. 60 minute duty at lowest RPM.
 (2) Washdown TEFC motors are rated for 10:1 C.T. 60 minute duty or 2:1 C.T. continuous duty at lowest RPM.

Application Notes

- Bearing currents** Marathon Electric recommends that any motors used with Variable Frequency Drives be equipped with suitable means to protect the motor bearings from shaft currents caused by common mode voltages inherent with operation on a non-sinusoidal power supply. Marathon Electric offers several options for motors in non-classified (non-hazardous) locations, including ground brushes, insulated bearings and non-contact shaft grounding rings. For more information on ground brushes and bearing currents, see the VARIABLE SPEED OPERATION section. For installation cost and available options, see the MOD CENTRAL section.
- Restricted use** DO NOT APPLY THE FOLLOWING MOTORS ON VARIABLE FREQUENCY DRIVES:
 Single Phase motors, Motors with inherent overload protection, Multi-Speed motors, Motors with 1.0 Service Factor on sine wave power.
 Fire Pump motors should not be used with variable frequency power supplies, due to the critical nature of these applications.
- Hazardous Locations** Consult with Marathon Electric when applying motors and drives into Hazardous Locations, either Division/Zone 1 or Division/Zone 2 areas. UL and CSA policies prohibit the installation of bearing protection devices, such as shaft grounding brushes, rings or insulated bearings on motors in Hazardous Locations.

Maximum Cable Lengths from the Motor to Drive

PRODUCT DESCRIPTION	3 HKz CARRIER FREQUENCY (PHASE TO PHASE)*		
	230 VOLT	460 VOLT	575 VOLT
56-326 NEMA, 100-225 IEC Frames	600 ft.	125 ft.	40 ft.
364-5013 NEMA, 250-315 IEC Frames	1000 ft.	225 ft.	60 ft.
Motors with CR ²⁰⁰ Corona Resistant Magnet Wire	1500 ft.	475 ft.	140 ft.
Motors with MAX GUARD [®] insulation system	Unlimited	Unlimited	650 ft.
Form-wound low voltage motors	Unlimited	Unlimited	650 ft.

* Higher carrier frequencies require shorter cable length to obtain normal (50Khrs) insulation life.

Standard Motor Insulation Systems

CR200 CORONA-RESISTANT MAGNET WIRE	Max Guard*
microMAX inverter duty	Black Max Vector Duty
"4 - in - 1" Three Phase, C-Face with Removable Base	Blue Max Vector Duty
Standard Three Phase stock Brakemotors	Three Phase PowerWash XT and SXT washdown
Blue Chip Severe Duty Explosion Proof, EPACT Efficiency	Blue Chip XRI Severe Duty
	Blue Chip XRI-841 (IEEE841 compliant)
	Automotive Duty "T" Frame
	Blue Chip Explosion Proof, XRI Premium Efficiency
	Globetrotter IEC Metric motors

VARIABLE SPEED INFORMATION

Marathon Electric Vector-Duty and Inverter-Duty motors, unless otherwise stated, are rated for continuous operation in a 40°C ambient and for altitudes up to 3300 feet (1000 meters) above sea level. Special application considerations, such as high or low ambient, intermittent ratings, high altitude, duty cycle rated, extended constant horsepower range, special base speed, voltage or frequency, or any other special requirements, should be reviewed by a factory representative.

It is the responsibility of the startup personnel during commissioning of the VFD/motor system to properly tune the drive to the motor for the specific application. The correct voltage boost and volts/hertz settings are application dependent and unique to each motor design. Procedures for these adjustments should be in your VFD user manual. Many Vector Duty and Inverter Duty motors in this catalog are equipped with thermostats; warranty coverage may be denied if they are not properly utilized.

⚠ WARNING *Power factor correction capacitors should never be installed between the drive and the motor.*



INVERTER DUTY OR INVERTER RATED

“Inverter Duty” (often called “Inverter Rated”) motors are suitable for use with Variable Frequency Drives, as long as operation is within the application guidelines published in this catalog. In general, Marathon Electric’s three phase, general purpose, NEMA Design B motors are considered “Inverter Duty”, and meet or exceed the requirements of NEMA MG1, Part 30. As required under Federal law, these motors comply with EPAAct efficiencies when operating from utility power.

Many of Marathon’s motor product lines have been enhanced to facilitate reliable operation on today’s variable speed drives, including wider constant torque speed range (up to 20:1) and improved insulation systems that withstand voltage spikes common with variable frequency operation.

Inverter Duty (Rated) motors are most often used in 10:1 speed range, variable torque or constant torque applications. A vector control is usually required for operation beyond 10:1 CT.

Refer to “Guidelines for Application of General Purpose, Single Speed Three Phase Motors on Variable Frequency Drives” in this section of this catalog for the allowable speed range and cable length restrictions (from VFD to motor). Additional detail regarding a specific product’s capabilities is available on its catalog page, or by consulting your application engineer.

VECTOR DUTY – “Vector Duty” describes a class of motors that are used in conjunction with Open- (without encoder) or Closed-Loop (with encoder) Vector controls, that provide enhanced performance under low speed operating conditions, or in cases where torque (rather than speed) must be controlled. “Vector Duty” motors can be applied to Volts/Hertz (scalar) drives, as well.

Marathon Electric’s “MAX” family, consisting of Blue Max®, Black Max® and microMAX™ motors, have been specifically designed for optimal operation on vector or volts/hertz controls. These motors feature a wide constant torque (up to 2000:1) and/or constant horsepower (up to 4:1) speed range and are performance-matched to all current technology IGBT drives. Vector Duty motors meet or exceed the requirements of NEMA MG1, Part 31, and are equipped with an enhanced insulation system (MAX GUARD® or CR²⁰⁰) to provide many years of trouble-free service. Consult the catalog page for each product’s capabilities and features. As these motors are specifically designed for operation through an inverter, they are exempt from EPAAct legislation. Model numbers contain the letter “H” in the “Electrical Type” field.

VARIABLE TORQUE LOADS – Applications include fans, blowers and centrifugal pumps. Torque varies as the square of the speed, and horsepower as the cube of the speed. Operation below base speed significantly lightens the load on the motor. While most variable torque applications do not require the motor to operate below half speed, the motor is fully capable of operation to zero speed. Operation above base speed significantly adds to the load on the motor; therefore, a factory representative must review applications requiring variable torque above base speed. Refer to the application chart found on page 14 for use of general purpose three phase motors on variable frequency drives. Marathon’s microMAX™, Black Max® or Blue Max® motors are not necessarily required for operation of variable torque loads. A bypass circuit is often employed in Variable Torque applications. If this device is intended to be used, selection of a NEMA Design B motor is recommended, to withstand the inrush current during across-the-line starting.

CONSTANT TORQUE LOADS – Applications include conveyors, elevators, hoists, extruders, positive displacement pumps, mixers and converting equipment. Torque remains constant throughout the range of operation, and extra care should be taken in the proper application of motors, especially at very low speeds. Most constant torque applications don’t require operation below 10:1 (i.e. 6 Hz operation on a 60 Hz motor), but an increasing number of applications historically reserved for servo and/or stepper systems are being served with motors capable of operation beyond 20:1...even up to 2000:1 (zero speed, constant torque). Refer to the application chart found on page 14 for use of general purpose three phase motors on variable frequency drives.

Continued on next page.

Variable Speed Operation

CONSTANT TORQUE LOADS (Cont'd.)

Applications requiring greater than 20:1 C.T. are ideal for microMAX™, Black Max® or Blue Max® motors. These motors provide full rated torque within their listed speed range, without exceeding a Class F temperature rating while under inverter power (many operate at Class B). Ratings in this catalog have been developed, based on extensive testing on IGBT inverters, set at a minimum 3 KHz (or equivalent) carrier frequency.

Vector Duty and Inverter Duty motors from Marathon Electric are designed for operation at 150% of rated load for one minute, up to the base speed of the motor (overload capability declines to 100% as the motor reaches maximum constant HP speed). These motors accommodate constant horsepower operation to 1-1/2 to 2 times base speed, subject to the motor's maximum safe mechanical speed limit. Refer to the Maximum Safe Mechanical Speed Chart, as well as the performance section for each motor's capability.

Motors rated for zero RPM continuous duty (1000:1 or 2000:1) must be powered by vector drives to produce rated torque without overheating. Optimum zero speed and low-speed full torque performance may require a closed loop vector drive (with encoder feedback).

CONSTANT HORSEPOWER LOADS – Applications include coil winders, band saws, grinders, and turret lathes. Operation requires the motor to deliver the same horsepower rating, regardless of shaft speed. Torque increases at low speed and decreases at higher speed. Most general purpose motors can deliver constant horsepower up to 1 1/2 times base speed (consult a factory representative to verify performance). However, many constant HP applications require operation to twice base speed, and some, such as coil winders, up to 4 times base speed. microMAX™, Black Max® and Blue Max® motors are designed for 1 1/2 to 2 times base speed, and the Wide CHP motors, found in Marathon's SB371 Catalog, deliver up to 4 times constant horsepower performance.

BEARING CURRENTS – As stated in NEMA MG1-31.4.4.3, to protect a motor from inverter-sourced shaft voltages, either both bearings must be insulated or the motor shaft must be effectively grounded. Marathon Electric offers several effective means to protect the bearings from inverter sourced EDM (electrical discharge machining). A Shaft Grounding device is standard in Blue Max® motors, in frame sizes 444T and larger. Insulating the motor bearings will not prevent damage to bearings of a connected load, and insulated couplings should be employed to protect the load. Adding a ground brush to a motor with insulated bearings will divert motor shaft currents and help protect the bearings of the connected load. At this time, UL policy prohibits the use of ground brushes or insulated bearings in Hazardous Locations (Div 1 & 2, Zones 1, 2, 21 & 22).

MOTOR GROUNDING - Frames and accessories of all motors must be grounded in accordance with the National Electric Code (NEC) Article 430. Refer to NEC Article 250 for

general information on grounding. Proper grounding of inverter-driven motors is essential to protect personnel and livestock from inverter-sourced common mode voltages, which may reach hazardous levels on the frame of ungrounded or poorly grounded motors.

LOW INPUT VOLTAGE – If, due to lower utility supply voltage, the input voltage from the VFD to the motor is lower than the motor's rated voltage, de-rating of the motor's base frequency, horsepower, full load RPM, and constant HP RPM is required. The revised values can be calculated by multiplying by the ratio of the voltage change. For example, to operate a 460 volt motor from an inverter fed by 50 or 60 HZ, 400 volt utility power, the multiplier is 400/460 or 0.87.

The VFD can be reprogrammed to match the new base point values, allowing the motor to provide rated torque at rated current from the new base speed down to its original minimum Constant torque speed. The motor's CHP range will begin at the new base frequency and will be shortened by the same ratio as described above.

OVERSPEED CAPABILITY – Maximum safe mechanical speed capability is a function of bearing size and type, lubrication, rotor balancing technique and specifications, air gap, enclosure, frame construction and connection to the driven load. In addition, consideration must be given to ambient noise levels, as operation above base speed will increase motor noise and vibration, and reduce bearing life. Under no circumstances should bearing hub temperature exceed 100° C. Belted loads should not exceed 60 Hz operating RPM by more than 25% (NEMA "TS" shafts are not suitable for belted loads). Due to external cooling fans, TEFC (and Explosion Proof Fan Cooled) motors are limited to 4000 RPM maximum speed.

Marathon Electric, through extensive testing in our state-of-the-art laboratory and in actual field experience, has developed a number of high speed motors whose maximum safe mechanical speed exceeds the values in the table below. The following table depicts maximum safe speed limits for continuous operation, direct-coupled, non-explosion proof motors, and does not imply constant horsepower capability. Please consult a factory representative for requirements beyond those listed, or for intermittent duty limits.

Maximum Safe Mechanical Speed Limits (ODP, TENV, DPFV OR TEBC ENCLOSURES) 60 Hz base frequency

Frame Size	2-Pole	4, 6 or 8-Pole
56-184	7200	5400
213-256	5400	4200
284-286	5400	3600
324-326	4000	3600
364-365	4000	2800
404-449	3600	2800
5000 Fr	N/A	CALL
6800 Fr	N/A	CALL

VARIABLE SPEED OPERATION

OTHER APPLICATION CONSIDERATIONS –

For proper selection, the following should be considered:

- Horsepower or torque requirements at various speeds.
- Desired speed range of the load and motor.
- Acceleration and deceleration rate requirements of the process being controlled.
- Starting requirements including the frequency of starting and a description of the load (reflected inertia at the motor, load torque during starting).
- Whether the application is a continuous process or duty cycle of starts, stops and speed changes.
- A general description of the type of application including the environment in which the VFD system components must operate (determines motor enclosure and/or explosion proof classification).
- Description of the available electrical power supply and wiring.
- Special performance requirements, if any.
- Whether the drive will be configured with a by-pass circuit. In case of its deployment, the motor will operate like its fixed speed counterpart and may require a NEMA B design which limits in-rush current, or selection of a larger motor starter or other protective circuitry.
- Load sharing
- Mounting and other mechanical considerations

Typical Temperature Rise Of Various Enclosures

