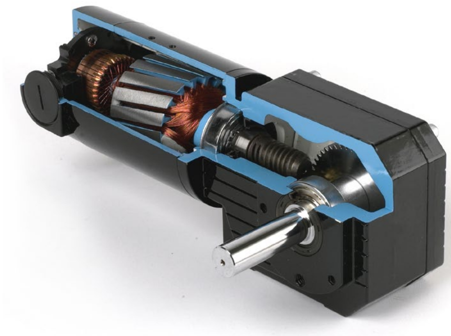
The Engineer's Guide to AC Gearmotor Nameplate Ratings

When it comes to powering industrial and commercial machinery, single-phase AC gearmotors are a popular choice. These compact, integrated units combine an AC motor with a gearbox to deliver power and torque efficiently. Single-phase AC gearmotors can operate directly from standard wall outlets, making them more accessible for general-purpose use. They are ideal for fixed-speed operations in conveyor systems, packaging machinery, chemical injection pumps and food service equipment.

Integral gearmotors offer significant advantages compared to pairing a separate motor and gearbox. Having a single, cohesive unit eliminates alignment challenges, leading to quieter operation and increased energy efficiency. This extends the lifespan of the gearmotor. Gearmotors also minimize the need for additional components, such as couplings or extra bearings, which are often required when using motors and gearboxes from different manufacturers.



BODINE ELECTRIC COMPANY

In this whitepaper, we will take a deep dive into the nameplate ratings of single-phase AC gearmotors, and how to interpret their specifications for optimal performance.

Common misunderstandings when interpreting gearmotor nameplate ratings

When examining the nameplate ratings on an integral gearmotor, esngineers often assume that these ratings are perfectly aligned between the motor and gearbox. "Unfortunately, that's not always the case," says Terry Auchstetter, director of marketing and product development at Bodine Electric. "Motor ratings are based on thermal limits, whereas gearbox ratings are based on life ratings."

In other words, the safe operating point for a motor is based on the maximum temperature associated with its insulation class; Class B motors, for example, are rated to 130°C, while Class F motors can operate up to 155°C. On the other hand, gearbox ratings are dictated by life factors, such as gear wear, bending capacity or bearing loads. When combined into an integral gearmotor, the system is rated according to the lower limit of these two factors.

"With a stock product line, you can't have a different motor size for every gear ratio — so we pick a reasonable motor size and might have ten different gear ratios to go with it," says Auchstetter. "In the case of high gear ratios, we hit the gear limit before we hit the thermal limit of the motor."

Another common misunderstanding is the relationship between the gearmotor's current rating and torque. Unlike brushless DC or PMDC motor types, single-phase AC motors do not exhibit a direct relationship between current and torque. This creates a false sense of security when engineers monitor current alone, thinking they are staying within the operational limits of the gearmotor. So, while adding a five-amp fuse may protect the motor from overheating, the gearmotor may still strip its gears if the torque exceeds gearbox limitations.

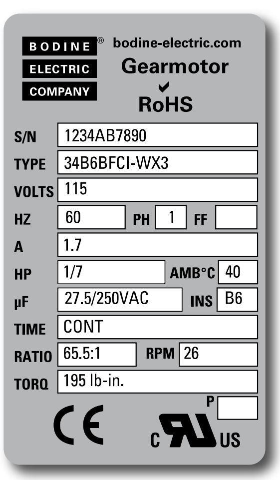
The underlying takeaway is to always consult with the manufacturer.

"Back in the old days, the first thing a design engineer would do was call the company directly because there was no website to download data sheets from," says Auchstetter. "Now, design engineers think everything they need is available online, and they try to do everything themselves. But there's a lot that you can't get on the website, and you need to talk with the manufacturer to fully understand what's behind those ratings."

How to interpret AC gearmotor nameplate ratings

The nameplate on an AC gearmotor serves as a reference to key operating parameters and restrictions. Misinterpreting these specifications can result in several undesirable consequences.

Here's a breakdown of the fields on a typical gearmotor nameplate.



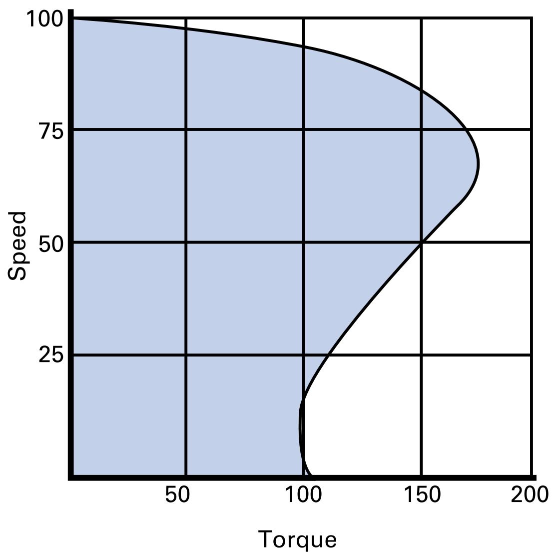
S/N: The serial number is a unique identifier for a specific gearmotor built to a specific design revision and on a specific manufacturing date. This is the number that a customer would give to the manufacturer to determine if the product is still within its warranty period.

TYPE: Product type.

The product type encodes details about the motor's frame size, type and length. For instance, "34R6" denotes a size 34 motor, an AC motor type ("R") and a specific length ("6"). "B" differentiates whether the motor has an accessory shaft on the opposite end of the drive shaft, which could be used for a brake or an encoder. "F" distinguishes whether the motor is totally enclosed non-ventilated or, in this case, fan-cooled. "CI" is Bodine's code for a permanent split capacitor-type AC motor, while "WX3" indicates the gearmotor type. For Bodine, the product type is also a means to cross-reference to a third-party testing file, such as UL and/or CSA.

VOLTS: Voltage at which the motor is designed to operate.

While there is some built-in tolerance for short periods of overvoltage, certain motor designs are more tolerant than others. In general, operating above the specified voltage increases the risk of overheating, while operating below it can cause stalling.



"We specify a tolerance for AC voltage, whereas we don't for DC," says Auchstetter. "While speed is proportional to voltage in DC motors, AC motors don't have a linear speed-torque curve — the graph has a hump. If you reduce the voltage, you reduce the torque, and you can start to get close to that hump where the motor just stalls."

HZ: Frequency of the AC power supply at which the motor is designed to operate.

Most motors in the U.S. are rated for 60 Hz since that is the frequency available through standard wall outlets. Deviations from rated frequency in a single-phase motor can cause overheating and damage to the winding.

"Unlike a three-phase motor designed for operation with an inverter, which allows for a wide range of frequencies, a single-phase motor should be limited to the frequency that's displayed on the nameplate," says Joe Norris, director of electrical and electronics engineering at Bodine. "Some 60 Hz motors can tolerate operation at 50 Hz — but unless it's stated directly on the nameplate, it should be avoided, or the manufacturer should be consulted."

PH: Number of phases — either single-phase or three-phase.

FF: Form factor (not applicable to AC motors).

A: Current rating.

The current rating is an indication of where the motor — not the gearmotor — will be when operating at full horsepower rating. As mentioned earlier, there isn't necessarily a direct relationship between current and output torque.

"The current rating is useful for end users when sizing fuses, circuit breakers or branch circuit protection in their machines," says Auchstetter. "Typically, you size it about 20% above the current rating of the motor to avoid nuisance tripping."

HP: Horsepower at which the motor has been deemed to operate within the specified duty cycle and insulation class.

AMB°C: Maximum ambient temperature the motor has been qualified to operate within at the horsepower rating on the nameplate.

"If you're operating at an elevated temperature range, you need to let the manufacturer know," says Jay Cacal, design engineering manager at Bodine. "We can design something to work in that environment. We've designed motors to operate in ambient temperatures as high as 70°C."

"We need to go back and review the design for the specific application and motor being considered," says Norris. "If there's adequate margin, we may allow for operation at a higher ambient temperature. If not, we have options — like using a different insulation class, changing the winding or adjusting the capacitor rating."

It should be noted that the motor winding is not the only concern when operating a motor at elevated temperatures. The lubricant used in the motor bearings and in the gearing reservoir also have a temperature rating. As a general rule, ball bearing or gear lubricant life is halved for every 25°F (14°C) increase in temperature.

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> — Jay Cacal, Design Engineering Manager, Bodine

INS: UL-recognized insulation class designation of the motor.

In the example above, "B6" indicates a UL Recognized insulation system specific to Bodine Electric motors that operate at a maximum temperature of 130°C. Operating beyond the temperature rating of the motor will reduce the life expectancy of the motor winding. Generally, the motor insulating life is halved for each 10°C increase in total temperature.

Insulation Class	Maximum Hot Spot Temperature	
	°C	°F
A	105	221
E	120	248
B	130	266
F	135	311
H	180	356
N	200	392
R	220	428
S	240	464
C	Over 240	Over 464

µF: Capacitor rating.

The listed capacitor is specifically designed to operate with its winding. For the permanent split capacitor-type motor in the example above, performance is optimized with a 27.5 µF capacitor operating at a recommended voltage of 250 V.

"Consult with the manufacturer if you don't have a 27.5 µF capacitor," says Norris. "We strive to provide capacitor ratings that fall within industry standards, so these are commonly manufactured by capacitor manufacturers. Sometimes, however, a customer may want to use a 30 µF or a 20 µF capacitor. Increasing the capacitance rating will increase the starting torque of the motor but will also result in higher temperatures. Decreasing the capacitance rating will lower the starting torque but will also reduce the operating temperature and overall performance."

Sometimes, the manufacturer may recommend a higher voltage for the capacitor. In these scenarios, using a 250 V capacitor — for example — when a 500 V rating has been specified, would dramatically shorten the capacitor's life.

"To ensure the capacitor's longevity and prevent overheating and damage, you need to size the capacitor for at least as large a rating as what's specified on the nameplate," says Norris. "It's okay to use a larger voltage rating — it is not okay to use a lower voltage rating than what's specified."

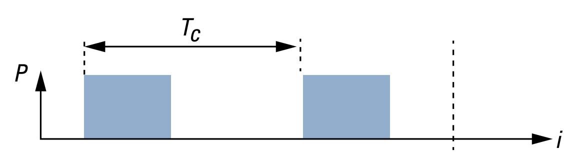
TIME: Duty rating.

The motor in the example above is specified as continuous duty, which is how Bodine designs their stock motors. However, there are special applications where the time rating is intermittent.

"Our motors typically follow different classes of intermittent duty as defined by IEC standards," says Norris. "For example, an 'S2' type intermittent duty rating with an indicated time of 60 minutes means you can run the motor for the full 60 minutes, followed by a period where it must cool back down to ambient temperature before being allowed to operate for another 60 minutes."

Continuous Duty Operation

Short Time Duty



Intermittent Duty Operation

RATIO: Gear ratio.

RPM: Speed of the output shaft (not the speed of the motor).

Motor speed can be determined by multiplying the gear ratio by the speed listed on the gearmotor nameplate.

TORQ: Output torque rating of the gearmotor.

"When we put a torque rating on the nameplate, it's not meant to show the full capability of the gearmotor — it's a safe limit," stresses Auchstetter. "The design engineer must make sure that the gearmotor never exceeds that load, except maybe for short bursts of starting torque and peak loads."

Bodine's gearmotor expertise

Bodine's understanding of nameplate ratings has helped design engineers address diverse application challenges. For instance, a grocery store checkout conveyor manufacturer faced issues with items toppling over due to excessive starting torque. By using test data to adjust the capacitor rating, Bodine provided a weaker motor that operated smoothly without overheating.

In another case, Bodine employed torque equations to help a gearmotor customer address an incidental requirement at Japan's lower voltage of 100 V.

"We have design and application engineers available to help customers make sure they're selecting the right gearmotor," says Auchstetter.

"Share as much information as possible about the application with us — whether it's related to load, environmental conditions or other factors," advises Cacal. "That enables us to design a long-lasting product tailored to meet all of our customer's specifications."

To learn more about how AC motors are constructed and how they operate, visit bodine-electric.com/ac-gearmotors-and-motors-online-handbook.

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