The Engineer's Guide to Choosing Gearmotors for Dirty and Wet Environments

Selecting the right gearmotor for an application often involves more than just knowing the volts, speed and torque that are needed. In some applications, it is just as critical to understand the environment the gearmotor must survive in and to choose a product constructed for use in that environment. Some environments can be especially harsh on gearmotors. One such environment involves extreme temperatures — either very hot or very cold, or even both.

"High temperatures are tough on the lubrication inside the gearbox" says Manny Morales, vice president of engineering at Bodine Electric. "You also have thermal expansion considerations, and the effect that heat has on the electrical performance of the motor."

Cold temperatures present different problems for the lubrication. "A gearmotor designed for an operating ambient temperature of 0° C to 40° C may not work so well at, say -25° C," explains Terry Auchstetter, director of marketing and product development at Bodine Electric. "A normally fluid lubricant may become viscous or even solid at extremely low temperatures, resulting in high current draw or even stalling of the motor." Extremely cold temperatures can also make permanent magnet DC motors vulnerable to demagnetization when overloaded.

BODINE ELECTRIC COMPANY

This whitepaper explores one category of harsh environments, which is dirty and wet environments that require superior ingress protection on a gearmotor. It explores how to choose gearmotors for dirty and wet environments by examining the standardized Ingress Protection (IP) ratings, explaining what design trade-offs are involved in achieving ingress protection, showing how the motor design is validated for a specific IP rating, examining mistakes engineers sometimes make in selecting a gearmotor, and presenting real-world examples of gearmotors used in dirty and wet environments.

Outdoor environments bring other challenges because the gearmotor may be subjected to both extremes in temperature relatively quickly. “Sudden temperature changes can affect the motor performance when you have it in the blazing sun, and all of a sudden a storm comes by and rapidly cools it down,” says Al Krajecke, industrial design engineer at Bodine. “The pressure differential inside the motor from the expansion of air can suck in some of the moisture as the motor cools.” Outdoor environments can also subject gearmotors to the ravages of dirt and rain, which can be especially harsh when driven by strong winds.

Understanding Ingress Protection Ratings

The IP (Ingress Protection) rating system, defined under the International Electrotechnical Commission (IEC) standard 60529, describes how well an enclosure of electrical equipment resists solids and liquids. The code consists of two digits: the first indicates protection against solids such as dust, while the second indicates resistance to water ingress. For example, an IP44 motor is protected against small objects down to 1 mm and resists splashing water from any direction. IP69 ensures complete dust protection and resistance to high-pressure, high-temperature water jets. See Figure 1 for a complete list of the defined IP ratings.

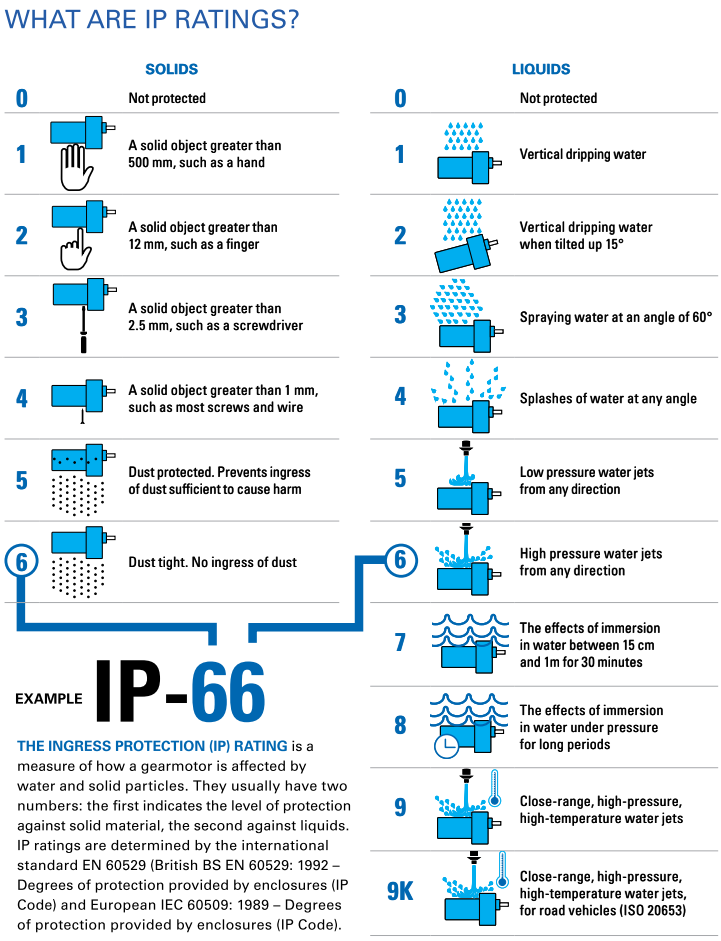


Figure 1: An explanation of IP ratings as defined by the IEC in standard 60529.

THE INGRESS PROTECTION (IP) RATING is a measure of how a gearmotor is affected by water and solid particles. They usually have two numbers: the first indicates the level of protection against solid material, the second against liquids.

Designing Gearmotors for Dirty and Wet Conditions

For gearmotors operating in dirty and wet environments, achieving high IP ratings requires specific design elements. Motors designed for high IP ratings are often totally enclosed and non-ventilated, which means they lack fans to dissipate heat. Without forced air, the question becomes how to prevent overheating in a sealed design.

"Because you're completely closed up and don't have a fan to help cool the motor, a common strategy is to use a larger motor to reduce its thermal loading," explains Morales. "But of course, you have to pay a little more for that because you have more material than you would need normally under different circumstances."

A totally enclosed motor alone isn't enough for higher IP ratings. For IP44, it might mean the addition of a liquid gasket (sealant) applied to the mating surfaces between the motor center ring and the two endshields, and a cable gland or terminal box at the lead exit.

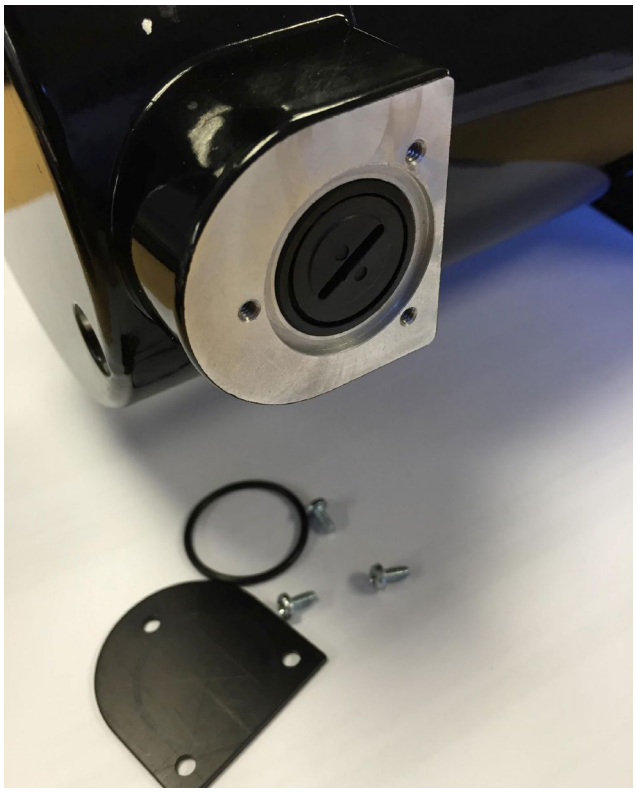


Figure 2: A sealed brush cap cover shown removed from a Brush DC Motor.

For IP66, it might mean adding O-rings instead of a liquid gasket to the mating surfaces, and an even better means of sealing the lead exit. Sealing washers might be used under the screws that hold the motor assembly together. And on brush-type DC motors with replaceable brushes, the brush caps must be sealed with either O-rings or gaskets (See Figure 2).

IP69K builds on many of the same sealing features as IP66 but has welded construction with integrated wiring compartments rather than added as separate parts, which helps reduce the points of ingress. Cable glands with IP69 ratings are used to withstand the high pressures and temperatures of washdowns.

In food and pharmaceutical environments, motors are often specified in stainless steel or finished with corrosion-resistant coatings, since frequent washdowns are expected. As Auchstetter notes, "Even if a painted motor might satisfy the requirements of the IP test, over time the paint can peel off with repeated high pressure, high temperature and corrosive cleaning materials. Paint peeling is not a good thing, especially with food contact involved."

Even if a motor is designed with superior water ingress protection in mind, the motor could still fail due to improper installation. For instance, a motor with a terminal box shipped from the factory may have an IP rating that is contingent on the installer using an appropriate fitting at the cord exit. Using the wrong fitting, or installing it wrong, could allow water ingress. Besides the initial installation, care must be taken later during maintenance. Brush-type DC motors, for example, need to be properly resealed after changing brushes to avoid future ingress.

"The IP rating is only as good as the installation of the motor," Auchstetter cautions. "If the installation isn't done according to the motor manufacturer's instructions, then all of the care taken in design and manufacturing will be for nought."

How Gearmotor Designs are Validated for an IP rating

Validating the IP rating of a motor depends on the level of protection. IP44 and below can be tested and self-certified in-house by the manufacturer using specialized equipment (See Figure 3). Higher ratings will often require third-party verification. Bodine Electric Company works with Underwriters Laboratories (UL) for IP testing.

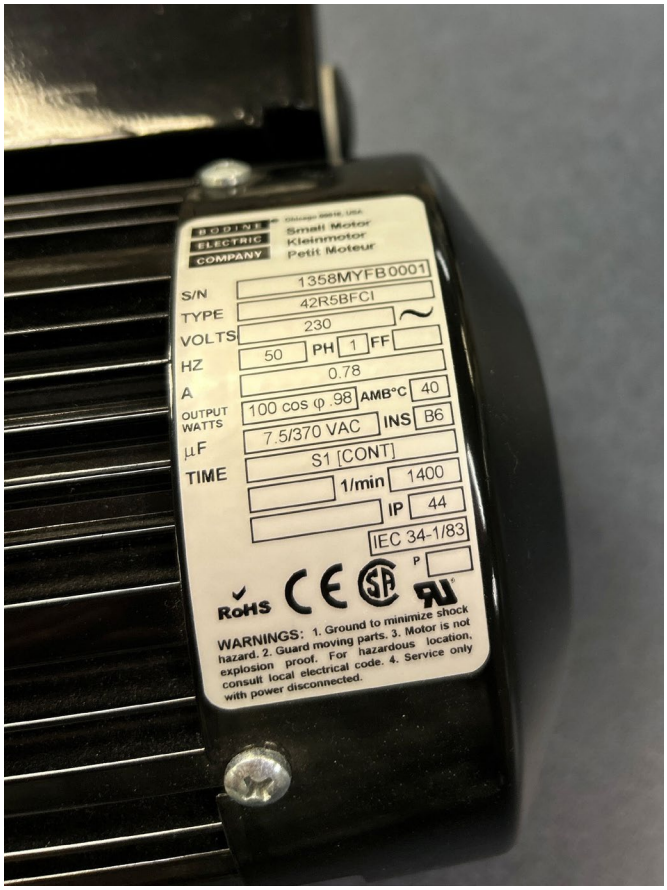
Figure 3: A gearmotor being tested for the IP44 standard.

> "One problem I've seen over the years is not having a consistent understanding of what washdown means. I've heard different customers use the term to mean different things — and because of that, they might be picking the wrong IP rating for the motor in their application."

Proper Selection of Gearmotors for Dirty and Wet Environments

One of the most frequent missteps engineers make is underestimating ingress risks a motor may face. Too often, a motor is specified with a lower IP rating than the environment requires.

"One problem I've seen over the years is not having a consistent understanding of what washdown means," adds Auchstetter. "I've heard different customers use the term to mean different things — and because of that, they might be picking the wrong IP rating for the motor in their application. There's a big difference between washing down a farm machine with a garden hose and washing down food processing equipment where you're using very high-pressure water at high temperature, and often with chemicals."



In the end, choosing the right motor comes down to anticipating the worst case.

"An IP rating provides margin, not immunity," emphasizes Morales. "To extend a motor's service life, additional protective measures should always be considered — such as using covers or shrouds, selecting appropriate connectors and cable glands, and incorporating drip loops into motor cords."

So, when does it make sense to invest in a higher IP-rated motor instead of using a standard motor inside a sealed enclosure or shroud? "If you have an application that's going to require frequent washdowns, and you can't use a shroud or cover in your application due to size constraints or lack of space, it's better to consider a motor with the higher IP rating," says Morales.

Bodine offers several optional features to enhance protection on standard motors. These include diecast terminal box kits with gaskets that keep moderate water spray out of the motor (Figure 4). Another option is a rubber boot that fits over the end of a Brush DC motor, covering brush access points without the need for multiple sealing components (Figure 5).

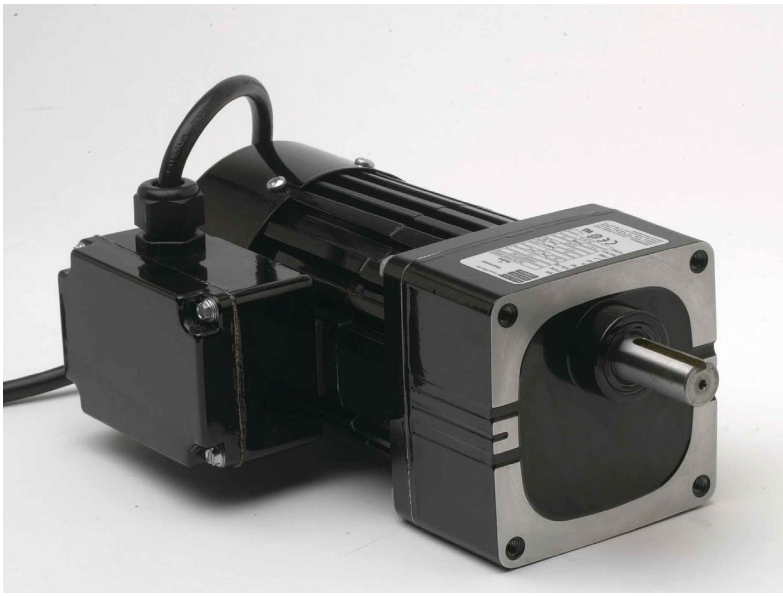


Figure 4: A die cast aluminum terminal box installed on a gearmotor with a gasket to protect the motor's wiring connections.

Figure 5: A Brush DC motor with a vinyl boot covering the end of the motor to protect the lead exit and cover the brush caps from water ingress.

Bodine Electric Company's Expertise in Real-World Applications

Bodine Electric Company's experience adapting gearmotors for dirty and wet environments shows up in projects across various industries. In one case, a manufacturer of motorized tarps to cover the load of a dump truck needed a gearmotor to withstand the rigors of an outdoor environment subject to frequent rain. A gearmotor with an IP44 rating, paired with a plastic shroud, provided the solution.

In the oil and gas sector, pipelines in remote locations require chemical injection to keep water vapor from freezing and to prevent internal corrosion. The pumps that meter those chemicals are subject to harsh outdoor conditions. To handle the exposure, Bodine Electric modified one of their standard gearmotors with additional sealing measures that made them more resistant to the outdoor effects.

Figure 6: An IP66 rated gearmotor installed on a seed planter operated in harsh outdoor conditions.

Figure 7: Two IP66 rated DC motors on a cake decorating machine.

Another outdoor application involved farm machinery, which obviously gets dirty and must be washed. And precision agriculture equipment is sometimes operated out in the rain. An additional challenge for the seed planter was that the gearmotor had an encoder that had to be protected as well as the gearmotor itself. Bodine Electric created a custom IP66 variation of their battery-powered gearmotor especially for this application.

Even in controlled indoor environments, Bodine has supported engineers in planning for extremes. One warehouse project required water-resistant motors for autonomous robots — not because of everyday conditions, but in case sprinklers activated during a fire alarm. "It seemed like such a remote possibility to me, but they were designing for the worst case," says Auchstetter.

Another indoor application involved a machine for decorating cakes. Though not as demanding as other food industry machinery, especially those in meat production plants, this machine still needed frequent washing and a motor rated IP66 was specified.

"Bodine Electric Company offers many different products and many different custom variations of those products to provide the gamut of protection requirements for a wide range of applications," adds Auchstetter. "We have application engineers to walk the customer through selection, and we have experienced sales representatives in the field to talk one-on-one about what different options are available."

To learn more, visit Wet & Dirty Location IP-44 / IP-55 / IP-66 / IP-69K Gearmotors.

BODINE
ELECTRIC
COMPANY