HOW TO GET THE RIGHT ELECTRIC MOTOR

HECO

All systems go

You need a motor. Now what?

Maybe you need a new electric motor. Maybe you need to get a previously owned one. In either case, there are some mighty important questions to ask yourself before picking up the phone and placing an order. If you make the wrong call, it can cost you — big time.

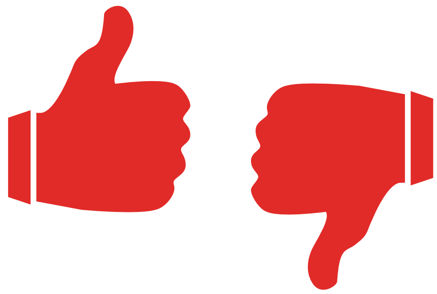
The purpose of this eBook is to give you some tips to help make sure you don't make that costly mistake.

OK, you need another motor – why?

This is, without question, no second thoughts allowed, the most important question of all. Exactly why do you need one? Was there a failure with a current motor? Has this exact same failure or one very similar occurred before? If so, maybe the motor was not the best available motor for the application. Here are some things to ask yourself in that regard:

- **Did the motor have the wrong enclosure?** Is this an open motor that is exposed to the environment? Would a totally enclosed motor still be running?
- **Did the motor have the wrong horsepower?** Was there enough horsepower to handle the load? Are you sure?
- **Is the motor on a VFD?** Is it grounded in some way to remove the circulating currents? Is the opposite drive end insulated?
- **What else?** There are a variety of items that can be mishandled or misapplied. Go over them all to get a handle on the situation when the motor went down.

It is important that you go over every aspect of why the motor failed. If you don't figure out why it happened – how on earth can you prevent it from happening again? Here's a worse-case scenario: What if you buy a replacement motor (new or used) and it fails, too? You would have been a lot better off evaluating why the first one went down before writing a check for another one. Right?



You've decided on a motor. Sure it's the right one?

Before that piece of equipment arrives on your doorstep, it's good to do some double checking. Who is supplying the motor? To what spec? How has the motor been sized? How have you decided what features are required? Which manufacturer makes that motor? Is it a one-off motor or a stocked catalog motor?

These aren't easy questions to answer. It all depends on your situation, your plant floor, your industry, your company.

Again, this eBook is not meant to provide you with all of these answers. Instead, think of it as a guide to lead you down the correct path to get the answers. What works in one industry may not be necessary for you. What matters most is that you take a path that will provide the most long-term reliable solution.

So… where to start?

National Electrical Manufacturers Association

Do you need a NEMA standard motor?

Hey, don't worry. This isn't complicated — especially for NEMA (National Electrical Manufacturers Association) regulated motors. For most ¼hp through 400hp standard motors, there are already standards in place. Here is some information you should know in order to decide what makes sense for you.

Basic NEMA Enclosures:

- **Open Drip Proof (ODP):** Open enclosures permit the free flow of cooling air. These motors have internal fans to assist air movement. ODP motors are designed to allow airflow, and prevent liquids and solids from entering the enclosure. ODP motors have vent openings and are constructed so that drops of liquid or solid particles falling on it, at any angle not greater than 15 degrees from vertical, cannot enter either directly or by striking and running along a surface of the motor.

Do you need a NEMA standard motor? *(continued)*

Basic NEMA Enclosures *(continued)***:**

- **Totally Enclosed Fan Cooled (TEFC):** Enclosed motors are designed for applications where contaminates are a factor, such as chemical plants, paper mills, and the outdoors. Enclosed motors provide for exterior cooling by means of a fan(s) integral with the machine, but external to the enclosed parts. These motors are the most commonly used motor in ordinary industrial environments.
- **Other Enclosures:** *There are other enclosures that exist, but are not as common as ODP and TEFC in industrial environments. However, they definitely are needed in certain circumstances.*
    - Other Totally Enclosed: Totally Enclosed Non-Vented (TENV), Totally Enclosed Air Over (TEAO), Totally Enclosed Air to Air Cooled (TEAAC), Totally Enclosed Blower Cooled (TEBC), Totally Enclosed Water to Air Cooled (TEWAC)
    - Other Open: Weather Protected I (WPI), Weather Protected II (WPII)

Do you need a NEMA standard motor? *(continued)*

Efficiency of NEMA motors

Since 2010, most standard NEMA motors manufactured in or shipped to the United States were required to be "premium efficient" designs. The Energy Independence and Security Act of 2007 (EISA) mandates efficiency standards for general purpose, three-phase AC industrial motors from 1 to 500hp that are manufactured for sale in the United States. The U.S. Department of Energy is responsible for establishing, implementing, and enforcing the rules.

When comparing new motor manufacturers, remember that efficiencies are regulated so they are all required to meet certain levels. If you go above these levels, you are typically going into high-cost, specialty-designed motors.

However, comparing a modern day motor to an older, less efficient motor, efficiency should most certainly come into play. It's been said that a motor's energy is 95% of its total lifetime operating cost, while maintenance and the initial purchase price are only 5%.

Do you need a NEMA standard motor? *(continued)*

Basic Motor Configurations

- **Standard Duty or General Purpose Motors**
  Typical "general purpose" motors can be either ODP or TEFC and are regulated to ensure that they meet NEMA's premium efficiency regulations. They typically have ball bearings (or roller bearings for high radial load belted applications) and can range from having a frame that is made out of flat rolled steel, cast aluminum, or cast iron. Warranties on general-purpose motors vary from brand to brand.

  General purpose motors are used in a variety of everyday, normal applications and industries including pumps, fans, compressors, conveyors, etc.

- **Severe Duty Motors**
  Severe duty motors only have TEFC enclosures. Features vary from manufacturer to manufacturer on what they consider severe duty. Here are some examples of what some major manufacturers say about their Severe duty motors:

  - **Baldor "Severe Duty" Motors**
    Totally enclosed cast iron construction • Premium insulation system • Sealed frame fits • Gasketed conduit box • V-ring shaft slinger • Stainless steel nameplates • Corrosion resistant epoxy finish and corrosion resistant hardware

    Super-E® severe duty motors have NEMA Premium® efficiency, Class F insulation • 1.15 service factor and 3-year warranty • Positive lubrication system (PLS) on 250 frames and larger • Motors are marked for Division 2/ Zone 2, Class I locations • Inverter-ready design

Do you need a NEMA standard motor? *(continued)*

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- **Severe Duty Motors** *(continued)*
  - **Siemens "Severe Duty" Motors**
    Cast iron TEFC enclosures • Die cast copper rotor or die cast aluminum that meets or exceeds NEMA MG1 Table 12-12 efficiencies • Class F insulation • Class B temperature rise @ 1.0SF • Equipped with drive end and opposite drive end shaft V-ring slingers for added bearing protection • Provisions for Inpro/seals on both ends • Cast iron construction • Polycarbonate fan • Zinc-plated hardware • Epoxy enamel paint and stainless steel nameplate resist rust and corrosion • Regreasable oversized bearings • Oversized gasketed, rotatable, cast iron conduit box.

    Severe duty motors are made for tougher applications and environments such as chemical processing, mining, foundry, pulp and paper, waste management and petro/chemical applications.

Do you need a NEMA standard motor? *(continued)*

- **IEEE 841 Motors**

  These motors are made to the IEEE 841-2009 standard for demanding environments that require more than just a severe duty motor. This specification covers three-phase motors from 1 to 500hp 1800rpm, 3600rpm, 1200rpm, and 900rpm.

  These feature all cast iron construction • Totally enclosed, NEMA Design B torque/current characteristics • Bearings with designed L-10 life • Limited shaft runout • Non-sparking fans • IP55 Cast iron terminal boxes • Sound limited to 90dB • Tested within the specifications low vibration tolerances • Corrosive-preventive coatings • Non-contacting–while-rotating seals with a minimum expected seal life of 5yr (Typically Inpro-Seal)

  Although these motors were specifically designed for the petrochemical and chemical industry, their premium features are used in a variety of industries and applications where:

  - Ambient Temp ranges from -25°C to +40°C
  - Maximum altitude of 1000m
  - Indoor or outdoor, humid, chemical (corrosive), or salty atmospheres
  - +10% of rated voltage @ rated frequency
  - +5% of rated frequency @ rated voltage
  - Combination of voltage and frequency variation of 10% within limits above

Do you need a NEMA standard motor? *(continued)*

Other industries where IEEE 841 motors can make sense are: Paper & Pulp, Steel Mills, Cement & Aggregate Plants, Power Generation, and any other industries that have harsh environments as indicated previously.

For further information in IEEE 841 specification motors, please see the IEEE website and download the entire spec at: https://standards.ieee.org/findstds/standard/841-2009.html

One last note on NEMA motors

There a few failure trends that are happening in industry today that should be considered when replacing or sourcing an electric motor. You will want to know:

- **Is the motor on a variable frequency drive (VFD)?**
  Consider adding a shaft-grounding device, such as an AEGIS shaft-grounding ring. Motors on variable frequency drives are subjected to circulating currents that discharge through the motor's bearings causing mechanical issues, including bearing failure and all the associated other risks with bearing failure. These devices divert these currents from the bearing to ground, saving the bearing and the motor from the damage they cause.

- **Is the motor on a belted application (pulley) or is it a direct drive (coupling)?**
  Motors on a belted application can experience excessive radial (side) loading. If this is the case, you may want to consider switching from a traditional ball bearing motor on the drive end to a roller bearing that is designed for this radial loading.

Do you need a NEMA standard motor? *(continued)*

So… what does all this mean?

With NEMA regulated motors (1/4hp through 400hp) you can use some already in-place standards. If your company is a clean environment, maybe ODP general purpose motors will work for you, if you are a harsh, dirty environment you may want to look at severe duty motors or even IEEE 841 motors.

Understand what you need and then you can specify to your vendor what you require and ensure you will be getting a motor that will be best for the application.

What about non-NEMA larger motors (400hp+)?

For ease of discussion, these motors are typically referred to Above-NEMA or A-NEMA motors. These questions are a bit tougher to answer. Typically, the approach that makes the most sense is to have some basic parameters that must be met by every A-NEMA motor you purchase. For instance, do you require:

- Any fans/baffle arrangements to be non-sparking
- Screens/filters to be re-useable and washable
- L-10 bearing life (100,000 hours)
- High permeability M19 silicon steel and C-5 insulation for laminations
- Core-loss test with thermal images with a temperature difference not greater than 5°C.
- Class F insulation system or better
- Vibration levels to be within API 541
- Copper-bar type rotor construction
- Sleeve bearings to be split for ease of maintenance
- Opposite-drive-end bearing housing to be insulated
- Jacking bolts for alignment purposes
- Specific electrical testing
- Hold points at certain steps of the manufacturing process
- Witness testing of certain tests by plant personnel
- Specific reporting of tests done
- A certain warranty

What about non-NEMA larger motors (400hp+)? *(continued)*

There are also specifications that you can require manufacturers to meet, such as:

- API 541 (Form Wound SCIM's 350hp+)
- IEEE 429 (Evaluation of Sealed Insulation Systems)
- IEEE 112 (Test Procedures for Induction Motors)
- IEEE 275 (Recommended Practice for Thermal Evaluation)
- IEEE 522 (Surge Comparison Testing)
- NEMA MG1 (Standards for Motors & Generators)
- ANSI C50.41 (Polyphase Induction Motors for Generating Stations)
- CSA C22.2100 (Motors & Generators)

Whether you choose one, a few, or all of these parameters, you will have leveled the playing field when you bid manufacturer to manufacturer. It may not make sense for you to include all of these, but make sure the ones that matter the most to you are specified!

There is tremendous value in saying "This is what I want." If you don't specify what you want, you will simply get what the manufacturer builds. It's like "apples vs. oranges." If you don't specify that everybody provide a quote on an "apple," and you just ask about a piece of fruit, you might get an estimate on an apple, an orange, or even a banana!

Beyond these "basic parameters" you should consider the individual motor's situation, application, and history when selecting a replacement or a new build.

What about non-NEMA larger motors (400hp+)? *(continued)*

First, you must be sure that the following nameplate listed and application requirement items are recorded and specified in your request for quote:

- **Horsepower**
  - Measurement of the motor's designed output rating.
- **Speed**
  - The revolutions per minute (rpm) of the motor at the nameplate rated voltage and frequency.
- **Voltage**
  - The rated voltage at which the motor is designed to operate – changes in voltage directly affect motor performance and reliability.
- **Full Load Amps**
  - The amperage that the motor will draw at full load/torque – this is used in selecting motor starter, which, if not considered, could cause starting issues.
- **Enclosure**
  - The degree of protection the motor has from the environment as well as the method of cooling.
- **Frame**
  - In motors 500hp+ there are still some NEMA standard frames, but there are also odd, manufacturer specific frames. This is not always available, and if not, an outline drawing becomes very important.

What about non-NEMA larger motors (400hp+)? *(continued)*

- **Mounting**
  - The method in which the motor is secured/fastened to the base. Typically rigid foot design or using a flange.
- **Frequency**
  - Generally given in hertz (Hz) – this is the frequency the motor is designed to operate at. Generally 60Hz in the US & Canada, 50Hz or 60Hz in other countries.
- **Service Factor**
  - Multiple of rated horsepower at which the motor can be allowed to operate continuously.
- **Ambient Temperature**
  - The maximum temperature of the area around and in which the motor will operate.
- **Altitude**
  - Only an issue in higher elevation areas; Air density decreases with increasing elevation – motors do not cool as efficiently.
- **Temperature Rise**
  - The increase in temperature above ambient that a motor is designed for.
- **Bearing Type**
  - Two main types: anti-friction (ball or roller bearings) or sleeve (Babbit).

What about non-NEMA larger motors (400hp+)? *(continued)*

- **NEMA Design**
  - NEMA defines 4 basic types of speed/torque characteristics for induction motors:
    - Design A: similar to Design B except higher breakdown torque and starting current
    - Design B: standard general purpose design for fans, blowers, pumps, etc.
    - Design C: high locked rotor torque for harder to start applications (conveyors, compressors)
    - Design D: high breakaway torque (275%+ of full load torque) with high slip. (stamping, cranes)
- **KVA Code**
  - Locked rotor kVA per horsepower per NEMA MG1 – a letter ranging from A to V – The higher the letter, the higher the inrush current per horsepower.
- **Starting Method**
  - Method in which motor is started: across the line (direct online “DOL”), variable frequency drive (VFD), soft starter, etc.
- **Accessories**
  - Any non-normal features such as RTD’s (bearing and/or winding), thermocouples, heaters, accelerometers, shaft grounding devices, special seals, proximity probes, filters, etc. You should specify what is required in an RFQ.
- **Environment**
  - Consider what environment the motor is exposed to: indoor or outdoor? Classified or non-classified area? Subject to saltwater/coastal concerns? Vaport, abrasive airborne particles? High humidity? Does the area the motor resided in get cleaned by sprayed water (washdown)?

Why spec parameters are important.

Many of the previous items, if not factored in when finding a replacement, can cause issues.

Let's just look at one that is not discussed very often, KVA code. This is the inrush current that the motor will draw when it is first started, assuming across-the-line start. Many times, KVA code is not even considered in replacing a motor, but if you don't, there is a chance the motor will not be able to start.

A motor's breaker needs to be able to handle the locked rotor, in-rush current of a motor upon startup. This is essentially the amount of amperage the motor will draw to get going, which is generally significantly higher than the nameplate-rated, full-load amps. Once going, the motor will only draw the rated nameplate amperage (full load at rated voltage).

Why spec parameters are important. *(continued)*

A common misperception

One common misperception is that if you start the motor under no load, the inrush current will be less. This is incorrect. Without a load, the motor will see the same inrush current as it does with the load. The only difference is that the motor will draw the inrush current for a longer period of time, due to the load.

Between this common misperception and a misunderstanding of what the KVA code actually is. You could buy a motor that will do everything your application demands (torque, speed, horsepower, voltage, etc.) but due to not factoring in one small factor, the motor may not work.

This is just one example. Similar situations apply for all of the items indicated that need to be checked.

Now, this information should be specified individually for each A-NEMA motor purchase – typically you are trying to match/replicate what was already in place. Or if it's a new application, you are trying to meet the demands of the driven equipment. Either way, covering all the data shown is a big step in the right direction.

Why spec parameters are important. *(continued)*

However, there is some more information that should be reviewed and provided to manufacturers, even after you have specified everything already discussed:

- **Drawings:** Any drawings that you have can provide tremendous value — especially an outline drawing of the original motor. You can then give that drawing to a replacement manufacturer to provide you their option, either a fabricated drop-in replacement or one of their standard motors with an adapter base. In either case, you can be assured that the motor you receive from the replacement manufacturer will match up to your base.
    - **Drawing of Connection Box Locations** – A drawing of your connection box locations can help ensure you do not have to do re-wiring when trying to install your replacement. Also, consider the location of auxiliary connection boxes for RTD's or heaters – the same rule applies – you do not want to have to re-wire to these if not necessary.
- **Speed v/s Torque Curve:** Providing a speed versus torque curve (that also shows Inertia WK2) for the load/application (for the pump, fan, compressor, etc.) allows for a double checking if the motor will be able to start the load.

Is a new motor really your best option?

Motor manufacturers sell on the fact that motors are getting smaller and smaller. Is this better for you as a user of electric motors? We think it depends on who you are and what you do. The simple fact is that motors were designed to last 25 to 35 years in the past, and were over-designed for what they were required to do. Modern-day, smaller, more efficient motors are designed to last 15-20 years. They are engineered with little to no leeway on what they are required to do.

The question: is it possible that you could purchase an older motor and have it re-manufactured in order to get that 25-35 years of life versus the 15-20 years out of a modern day motor? It may be possible, but it depends on the availability of an older motor, and the capability of a repair center to re-manufacture or re-engineer it for use in your application…. *But it IS possible*.

What if you don't have all the info and need to replace a motor?

There are other options that can be considered, but each path forward will be unique to what information is missing and/or available. For example, if you do not have an outline drawing of the original motor but would like to have a drop in-replacement, measurements can be taken onsite. These options exist dependent upon the missing information – but there are still options available so that you are not stuck without a replacement.

Help is available

HECO can help you with any questions you may have about whether you should get a new or used motor, and which manufacturer offers the motor best suited to your needs. We'll begin by asking "why?" Why do you need a motor? How will it be used? Where? Is it a replacement or an addition? What about spares?

Then we'll use our problem-solving and engineering expertise to keep your plant up and running. To learn more about what our "All Systems Go" approach can mean to you, please contact:

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