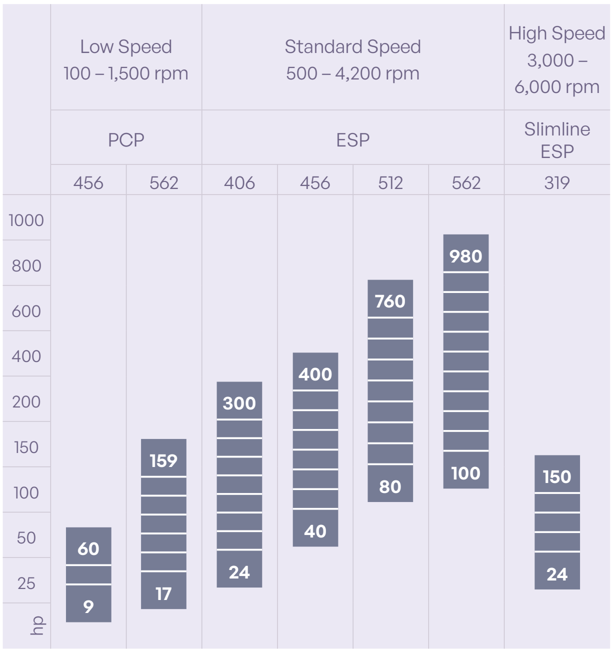
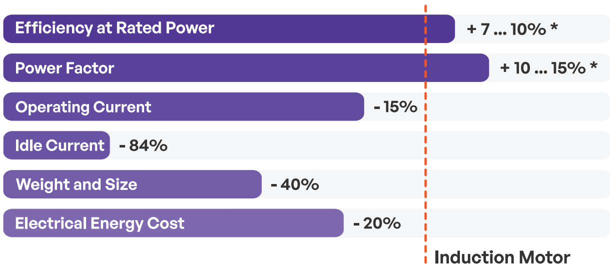
Permanent Magnet Motor FAQ

What is the largest horsepower PMM available in a 406 series? 456 series?

Available PMM Sizes and Horsepower Range



What are the advantages of running a PMM-ESP compared to using a conventional IM?



* depending on a motor size

Will running a PMM provide any cost savings to me?

Yes. While the PMM motor efficiency is estimated to be 7-10% better than an equivalent hp IM, PMM-ESP systems are estimated to reduce energy consumption by up to 20% when compared to a similarly operated IM system. For example, in west Texas where hundreds of unconventional wells are using ESP systems, this energy efficiency can result in several hundred (to millions) of dollars in cost savings and realizing the reduction of tons of CO_2 emissions associated with electrical power generation and consumption.

Do PMMs cost more than a conventional?

Typically, the downhole (PMM) motor is either similar or lower cost than an IM. All Levare PMMs are single-section motors. As a beneficial consequence of the higher horsepower rotor density, in some cases a single-section PMM can replace a tandem IM configuration to achieve equivalent horsepower, which often results in a net savings (fewer motor sections) and better reliability.

What are the unique HSE risks associated with running a PMM-ESP system?

Unintended shaft rotation causes a PMM to act like an AC generator and presents a risk of electric shock through the ESP power cable at surface. Fluid movement through the pump with the ESP not powered can be a potential source of unintended shaft rotation. With the ESP powered off, differential pressure and a communication path between tubing and annulus can result in fluid movement. Despite this potential hazard, all PMM-related activities can be considered safe as long as general field service safety precautions are followed. Levare has developed the Alert-RTS continuously monitoring system that eliminates unintentional shaft rotation while installing or pulling a PMM system.

What additional HSE precautions are taken during the install, troubleshooting, or pulling of a PMM-ESP system?

Aligned with the approach outlined by OHSA's Hierarchy of Controls, Levare has implemented additional Engineering and Administrative controls as well as utilizing specialized personal protective equipment (PPE) when handling, mobilizing, and operating PMMs for artificial lift applications. These include:

Engineering Controls

- Earth Ground Clamp – used to verify and insure adequate grounding (< 10 ohms) exists between spooling unit, wellhead, and other equipment and structures on lease premises.
- Shorting Box – installed at the spooling unit during install or pull, this device shorts and isolates the ESP power cable helping to act as an electrical "brake" in the event of any backspin-generated voltage.
- Physical Barriers – installed at the well site to prevent unauthorized or unnecessary access to personnel around equipment where the risk of electric shock exists.
- Recommended to use a downhole completion (such as drain/check valves, sliding sleeve, plug, etc.) device in the tubing string to establish or fully exclude communication and pressure equalization between tubing and annulus. The device is used to prevent unintended fluid movement through, and backspin in the downhole pump and motor.
- Warning Signage – installed on all ESP system surface equipment to identify, alert personnel to the presence of a PMM-ESP system installed in a well, and that appropriate caution must be exercised.

Administrative Controls

- Training and Certification – all Levare personnel involved in the handling, testing, deployment, and operation of PMMs are trained on the technical principles and associated risks. Furthermore, key personnel in the US are certified under NFPA

70e “qualified electrical workers”. Specific PPE equipment is tested and certified on a routine basis.

- Training on PMM operations and handling for customer well site personnel is also routinely provided by Levare.
- Hazard Recognition – A job safety analysis (JSA) including all on-site installation personnel is performed prior to each well site operation where specific hazards relating to PMM operations are identified and risk-mitigating actions implemented.
- Compliance Monitoring – compliance to PMM-specific procedures are audited and verified by Levare management on a regular basis.
- Procedural Adherence – strict adherence is paid to procedures for lock-out-tag-out, earth grounding, installation, pull, repair, commissioning, or troubleshooting.

PPE

- Dielectric gloves and matting
- Electrically rated footwear
- Protective face shields
- Voltage Detectors
- Amperage Clamp Meters

Do PMMs have more trouble than IMs operating in gassy conditions?

No. IM and PMMs respond to gassy conditions in the same manner. Since PMMs experience lower heat rise, they may even perform better than an equivalent IM in conditions such as continuous gas slugging where a PMM could endure increased heating for a longer duration. Consistent with greater efficiency, PMM idle current is typically much lower than for an IM. Consequently, when operating a PMM in gassy conditions, greater responsiveness to actual changes in the downhole motor load conditions may manifest as wider fluctuations in motor current observed at surface. Motor speed variation in the surface drive is often utilized as one method to help ESP systems overcome gassy production. Robust control algorithms utilized in Levare VSDs provide a variety of programmatic and more precise motor speed control enabling PMMs to ride thru and overcome gassy well conditions equal to or better than equivalent IM systems.

If a PMM-ESP experiences a short (grounded) condition while operating downhole, is there a risk of electric shock if I touch any surface equipment including the wellhead?

Practically speaking there is no risk of experiencing an electric shock at the wellhead when a PMM-ESP gets shorted downhole. When an ESP system is considered to have “grounded” downhole, current applied from a surface source will flow to the most conductive medium in the environment surrounding loss of insulation integrity. In a similar situation but with the source of current originating downhole (i.e., backspin), current would also tend to flow through the same short and be dissipated sufficiently within the subsurface so as to not present any appreciable risk of electric shock at surface. Any situation in which the condition of the downhole equipment is unknown still should be treated with caution. Other mitigating measures for operating with a PMM should still be followed such as eliminating simultaneous well opera-tions while installing or pulling a PMM-ESP system. The same safety precautions used for IM-ESPs should also be applied to PMM-ESPs. Precautions regarding the J-Box, step-up transformer, wellhead penetrator, upper pigtail, etc. must be equally applied.

How is a PMM for electric submersible pumping different from an induction motor (IM)?

Torque in an electric motor results when the rotor magnetic field interacts with the rotating stator magnetic field. The rotating stator magnetic field is established when a three-phase AC current is applied to the motor’s stator. The stator of a PMM is essentially identical to the IM stator. The main difference between IM and PM motors is in the rotor construction. The rotor in an IM is constructed using copper bars arranged longitudinally and shorted together at the ends. In the presence of the stator magnetic field, current is induced in the copper bars. This induced current generates its own (rotor) magnetic field, resulting in a torque on the rotor (and shaft) in the presence of the stator magnetic field. The PMM rotor has no copper bars and instead incorporates permanent magnets in its construction. These permanent magnets are the source of the rotor magnetic field. No current is induced in the PMM rotor, thereby eliminating electrical losses, reducing the heat generated, and resulting in a higher rotor horsepower (hp) density. The PMM rotor magnetic field (generated by the permanent magnets) exists independently of the rotating stator magnetic field. Consequently, the PMM motor performance and control stability requires that the rotor position be known to the surface drive while operating. Unlike induction motors, PMMs require a special control algorithm in the surface drive to optimize performance and maximize benefit.

Can your PMM run w/my existing VFD?

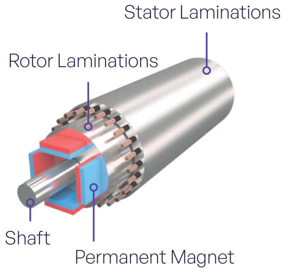
Levare has tested and qualified major VSD manufacturers to run its PMMs (list of all compatible VSD’s is available upon request from Levare representatives in all regional offices). While these other VFDs can operate and control the Levare PMM, the Levare Axiom II provides unique algorithms based on motor characteristics that allows more efficient and robust performance.

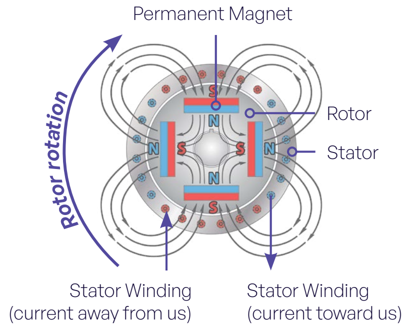
Can I run PMMs in tandem?

All Levare PMMs currently operate as single-section motors and cannot be run in tandem configurations. That said, the high rotor hp density available with PMMs means more motor hp is available in the shorter, single-motor section. Most applications are served by the horsepower available in the single-section PMM.

PMM Operating Principle

Permanent magnets made of sintered hard-magnetic materials are incorporated into the design of the PMM rotor. It is the rotor flux produced by these magnets that interacts with the stator magnetic field to produce motor torque. Power consumption and heat rise are both reduced since no current is induced in the PMM rotor.





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