Field Test of MagnaDrive Adjustable Speed Drive Technology

ET 07.19 Final Report

Prepared by:

Design & Engineering Services
Customer Service Business Unit
Southern California Edison

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EXECUTIVE SUMMARY

A significant portion of industrial electrical energy use is due to operation of electric motors running pumps, fans, or blowers. These loads could be met by operating the motor at less than full speed a large portion of the time, thereby reducing electrical demand and energy usage. This is most often done by use of an electric variable frequency drive (VFD) system which causes the motor to operate at varying speeds by varying the electrical frequency of the alternating current input to the motor.

There are alternative adjustable speed drive (ASD) systems that maintain the constant speed operation of the motor, but vary the load speed by means of a coupling that uses "slip" to allow the output drive speed vary as needed. One of these alternative technologies is the MagnaDrive magnetic coupling system. MagnaDrive appears to be well suited to a variety of installations, including applications using higher voltage systems, for which conventional VFD technology is not available, or is quite costly. This technology was selected by Southern California Edison (SCE) for field testing to evaluate its energy savings potential.

A test was conducted by SCE in cooperation with Searles Valley Minerals, a raw materials mining and production company, at their Trona, California, plant. Facility operations involve use of a number of large 480 V and 4160 V motor and pump systems. For test purposes, Searles provided SCE access to a 75 horsepower 480 V motor-pump system in which the motor operated the pump at constant speed before being equipped with the MagnaDrive ASD system. The tests provided data to determine the operating characteristics and energy efficiency benefits of the motor with the MagnaDrive ASD system compared to operating the same motor-pump system in its original constant speed mode.

To compare the performance of a VFD to the MagnaDrive system, the energy savings potential of a VFD in this analysis was obtained from Department of Energy (DOE) published data for a similar application with a 480 V voltage electrical system.

Compared to the constant speed system, the MagnaDrive system demonstrated that it could provide substantial kW demand savings at the Trona test facility, about 39% at a 50% pump flow rate and 22% at a 75% pump flow rate. However, the MagnaDrive savings were lower than the VFD savings, falling into the general range of 50-60% of the savings provided by the VFD system under similar conditions.

The smaller savings associated with the MagnaDrive system indicates larger losses are being incurred than for the VFD system, potentially causing overheating problems unless adequate cooling is accounted for in the design. This is not considered to be a serious problem for the MagnaDrive design because information obtained on previous MagnaDrive installations found no reports of overheating problems, and during the test at the Trona site no excessively hot areas on the MagnaDrive assembly were detected.

While the data indicates the VFD system would provide higher savings than the MagnaDrive ASD, the voltage level for the specific motors under consideration for the MagnaDrive ASD installations at the Trona site (4,160 V) is outside the primary range of VFD applications (up to 690 V) and would require a more costly and less available VFD design, tending to negate the benefits of VFD's energy savings potential.

It is recommended further work be done to obtain more detailed MagnaDrive ASD cost effectiveness data specific to the annual run time and duty cycle operations at the Trona site.
Other magnetically coupled ASD technologies competing with the MagnaDrive system were reviewed. The VFD systems are less expensive and more efficient at voltages less than 690V. It was concluded, however, that VFD technologies offered similar vibration, misalignment, operating environment, and power quality benefits as the ASD that Magna offers. However the ASDs are not produced in sizes over 250 horsepower and the MagnaDrive system would be the sole magnetically coupled ASD option for those higher horsepower applications.

In general, the MagnaDrive ASD should be considered for applications where the system voltage is above 690 V, and for systems below 690V where shaft misalignment, shock starts, vibration, power quality, and the VFD controller's need for a clean dry operating environment, are issues.
INTRODUCTION

A significant component of electrical demand and energy use is the operation of electric motors operating pumps, fans, or blowers. Often the load is variable and energy savings can be achieved by operating the load at variable speed. This is most commonly done by use of an electric variable frequency drive (VFD) system, which provides a means of controlling the motor to run at variable speeds to match load requirements.

There are alternative non-electronic adjustable speed drive (ASD) technologies that can be used to for variable speed load applications. One of these alternative technologies is the MagnaDrive magnetic coupling system, which appears well suited to a variety of installations, including applications using higher voltage systems for which conventional VFD technology is not available or is quite costly. This technology was selected by SCE for field testing to evaluate its energy savings potential under actual operating conditions at a site provided by an SCE industrial customer.

TECHNOLOGY TESTED

Adjustable speed drive (ASD) systems are installed with constant speed electric motors to allow the speed of the motor load to be varied to match the variable demand of the load, which, in turn, can reduce energy use compared to running the load at full speed at all times. The ASD technology evaluated in this test project was the MagnaDrive system, produced by the MagnaDrive Corporation, www.magnadrive.com. This technology adjusts the speed of the load by means of a magnetic coupling, involving no physical contact between the motor and the load. The lack of physical contact provides for a soft start for rotating equipment and minimizes vibration, shock loads, and misalignment problems. Also, the VFD controller's need for a clean dry operating environment is not an issue with the more rugged MagnaDrive system. When these conditions exist, savings in maintenance costs and equipment lifetime benefits can be credited to the Magnadrive system in addition to the energy savings. The MagnaDrive system does not induce the harmonic distortion power quality problems that are associated with electronic variable frequency drive (VFD) systems, which can be a problem in certain sensitive applications, such as semiconductor manufacturing.

In the MagnaDrive system, permanent magnets are attached to a rotating magnetic disk on the load shaft separated by a small air gap from a rotating conductor surface driven by the motor. As the motor spins the conductor rotor relative to the magnet rotor, the magnetic flux from the magnet poles bridges the air gap and creates eddy currents in the conductor rotor. The magnetic interaction between the magnets and the conductor rotor develops a force tending to turn the magnet rotor in the same direction as the motor driven conductor rotor. As the speed requirements of the load change, the space between the magnets is varied which changes the strength of the magnetic field and varies the load speed accordingly while the motor speed remains constant. The MagnaDrive magnetic coupling is located between the motor and the load, and requires adequate space for the installation. In some cases the motor and load configuration may require some rework, and add to the installation cost.

For lower voltage applications, up to 690V, VFD systems are readily available and economical. However, VFD systems for medium voltage applications, 690 V up to
6,600 V, are more costly and less available. VFD systems above 7,000 V are typically specialized designs and very expensive. On the other hand, the MagnaDrive system can be produced economically for very large systems, up to 4,000 HP, and can be easily applied to voltage systems above 690 V, such as the 4,160 V motor-pump systems common at the test site which are outside the primary range of VFD applications (up to 690 V).

MagnaDrive technology is commercially available and has been extensively used by the U.S. Navy in over a thousand applications. MagnaDrive technology has been increasingly used in recent years on fans, blowers, and pumps in commercial and industrial applications, such as office/hotel HVAC systems, paper mills, cement plants, wastewater treatment, and mining facilities.

**Testing Approach**

Testing was done as a cooperative effort with Searles Valley Minerals, a SCE customer. Searles Valley Minerals provided its Trona, California, facility as a field test site. Searles provided SCE access to a 75 horsepower 480V motor-pump system in which the motor operated the pump at constant speed, before being equipped with the MagnaDrive ASD system. Although many of the motor-pump systems used at the test site are operated at 4160 V, a 480 V motor-pump system was selected to simplify instrumentation requirements.

SCE provided cost sharing for procurement of the MagnaDrive system, provided instrumentation, and conducted on-site testing at the Trona facility to determine the achieved energy savings under actual operating conditions at the plant.

The instrumentation and test procedures were designed to provide test data to determine the operating characteristics and energy efficiency benefits of the motor with the MagnaDrive ASD system compared to operating the same motor-pump system in its original constant speed mode.

**Objectives**

The objectives of the field test were to:

- Demonstrate MagnaDrive adjustable speed operation with a pump running under representative on-site operating conditions.
- Document the level of performance and energy savings compared to operation of the pump at constant speed.
- Use the field test results and other MagnaDrive information to compare operating characteristics, energy efficiency, and applications of competing alternate magnetically coupled adjustable speed drive technologies.
FIELD TEST METHODOLOGY

Searles Valley Minerals is a SCE business customer willing to provide a field test site to work cooperatively with SCE to evaluate the energy savings associated with installing a MagnaDrive adjustable speed drive (ASD) system on a 75 horsepower constant speed pump motor.

SEARLES VALLEY MINERALS SITE DESCRIPTION

Searles Valley Minerals operates facilities to extract brines from the Searles Valley desert lake bed and produce minerals at three plants (Argus, Trona, & Westend) near Searles Lake, California. The Trona, California, facility operates with several large 480 V and 4160 V motor and pump systems and was chosen as the site for the MagnaDrive field test.

For the test, Searles Valley Minerals selected a 480 V motor-pump system in which the motor operated at constant speed, while plant operation required variable flow rates. The discharge flow rate was controlled by means of a control valve to throttle the flow to the desired level.

Installing an adjustable speed drive system would allow the flow to be regulated without the need to throttle the flow, and thereby reduce the electrical usage of the motor-pump system. Previous surveys indicated that electronic variable frequency drive (VFD) systems were not cost effective options for pump motors operating at 4160 V. Reviews of the cost and capabilities of the MagnaDrive magnetic coupling system indicated that it may be a cost effective option to provide the adjustable speed drive capabilities needed for pump systems operating at 4160V at the Trona facility. To verify the MagnaDrive system’s potential benefits, SCE provided instrumentation and conducted on-site testing at the Trona facility to determine the achieved energy savings under actual operating conditions at the plant.

INSTRUMENTATION AND TEST CONFIGURATION

The test installation included a constant speed 75 horsepower, 480V, 1200 RPM motor running a pump used to pump brine from one area to another. The MagnaDrive ASD unit was installed between the constant speed motor and the pump to provide an adjustable speed coupling for the variable speed portion of the testing as shown in Figure 1. Figure 2 shows the motor circuit breaker panel (left) and the MagnaDrive controller (right).

The instrumentation and test procedures were designed to determine energy efficiency of the MagnaDrive system. Other claimed benefits of the system, including soft start benefits, shaft alignment maintenance reductions, reduced vibration, and harmonic distortion advantages over VFDs were not included in this test scope.
FIGURE 1. THE MAGNA DRIVE ASD INSTALLED BETWEEN THE MOTOR AND PUMP

FIGURE 2. MOTOR CIRCUIT BREAKER PANEL (LEFT) AND MAGNA DRIVE CONTROLLER UNIT (RIGHT)

TEST PROCEDURES

The test was designed to compare the electrical use of the constant speed pump motor with the electrical usage of the same motor equipped with the MagnaDrive ASD to identify savings associated with the MagnaDrive system.

The system was set up for standard operation of the constant speed motor, with the MagnaDrive system disabled and non-operational. Data on electrical demand, flow rate, and pressure head was recorded for three flow rates, 71%, 83%, and 100% of
full flow. The variation in flow rates was obtained by use of a discharge control valve to throttle the flow.

The system was reconfigured with the MagnaDrive system operational. Data on electrical demand, flow rate and pressure head was recorded for six flow rates ranging from 38.86% to 100% of full flow.
RESULTS

DATA ANALYSIS

The data collected was used to obtain the pump system efficiency for the constant speed motor, and for the MagnaDrive system for the various flow rate values for which measurements were made.

To compare the performance of a VFD to the MagnaDrive system, the energy savings potential of a VFD included in this analysis was obtained from DOE published data\(^1\) for a similar application with a 480V voltage electrical system.

Pump system efficiency was calculated from the equation:

**Equation 1.**

\[
\text{Pump System Efficiency in } \% = 100 \cdot \left( \frac{\text{Output HP}}{\text{Input HP}} \right)
\]

Where Output HP and Input HP are calculated from the following two equations respectively:

**Equation 2.**

\[
\text{Output HP} = \text{Water HP} = Q \cdot \frac{H}{3960}
\]

Where:

- \(Q\) is the flow rate (GPM)
- \(H\) is the total pressure head at discharge (Feet)

**Equation 3.**

\[
\text{Input HP} = \text{Input kW} \cdot \frac{E}{0.746}
\]

Where:

- \(E\) is the electrical efficiency of the electric motor, 0.95 in this case
- KW to HP conversion factor: \(\text{HP} = \text{kW}/0.746\)

Measurements of pressure head and electrical kW data were recorded at a number of selected flow rates for both the constant speed and MagnaDrive variable speed operating conditions. This allowed the pump system efficiency to be calculated as a function of flow rate using Equation 1. These results are presented in Figure 3 in terms of system pump efficiency vs. percent of full flow, illustrating the significantly higher efficiency of the MagnaDrive system at all flow rates less than 100%.

Figure 4 presents the same data in terms of pump system input power, as a percent of full power vs. percent of full flow. This representation provides a percentage indication of the reduction in power demand (kW) associated with the MagnaDrive system compared to the constant speed system. In this case the MagnaDrive system requires less power at all flow rates less than 100%. For field engineering calculations, this chart presents data in the form most commonly utilized.

Figure 5 presents the data from Figure 4 along with additional independent data obtained from DOE tests\(^1\). The DOE testing includes data for the constant speed motor with discharge control and for an adjustable speed drive system using electronic variable frequency drive (VFD) technology. This chart shows that the
measured power vs. percent of flow data was similar for the constant speed test measurements at the Trona site and the DOE tests, indicating that the tests were conducted under similar conditions. Based on the DOE data for the VFD technology, the VFD operated at a lower power level than the MagnaDrive system for equivalent flow rates, indicating that the VFD technology was more efficient than the MagnaDrive technology. Mathematical curve fit equations were derived for the data sets involving the Trona test data and the DOE VFD data and included in Figure 5. This allows an estimate of the performance to be made at selected points such as 50%, 75% and 100% that may not have been a measured point.

Figure 6 presents a similar comparison of the Trona site test results and the DOE VFD data in terms of reduction in power demand (kW) of a 75 HP system representative of the Trona site, rather than in terms of percentage of full power as in Figure 5. Presenting the data in terms of kW reduction provides a more concrete illustration of the magnitude of the kW demand reduction achieved. The curves were plotted using the curve fit equations derived for Figure 5. In Figure 6, the measured data points were deleted, and commonly referenced points of 50%, 75% and 100% of full flow were identified. These points were used in a tabulation comparing kW savings and percentage savings of the MagnaDrive system and the VFD system compared to the Trona constant speed discharge controlled system (Table 1).
MagnaDrive Adjustable Speed Drive (ASD) Field Test
MagnaDrive ASD vs Constant Speed Motor
Pump System Efficiency vs Percent of Full Flow

FIGURE 3. MAGNADRIVE FIELD TEST RESULTS, PUMP SYSTEM EFFICIENCY COMPARISON
FIGURE 4. MAGNA DRIVE FIELD TEST RESULTS, PUMP SYSTEM POWER AS PERCENT OF FULL FLOW INPUT POWER
MagnaDrive Adjustable Speed Drive (ASD) Field Test
Trona Field Test Data vs DOE Data
Pump System - Percent of Full Flow Input Power vs Percent of Full Flow

\[ y = 20.566e^{0.0159x} \]

\[ y = 0.5156x + 48.447 \]

\[ y = 5.4755e^{0.0291x} \]

**FIGURE 5. MAGNADRIVE FIELD TEST RESULTS, PUMP SYSTEM POWER PERCENT COMPARED TO DOE PUBLISHED DATA FOR REPRESENTATIVE VFD SYSTEM**
MagnaDrive Adjustable Speed Drive (ASD) Field Test
Trona Field Test Data vs DOE Data
Pump System - Input Power kW vs Percent of Full Flow

FIGURE 6. MAGNA DRIVE FIELD TEST RESULTS, PUMP SYSTEM POWER (kW) COMPARED TO DOE DATA FOR REPRESENTATIVE VFD SYSTEM
**Table 1. Summary of MagnaDrive Test Results and DOE VFD Data**

<table>
<thead>
<tr>
<th>Pump Flow Rate (%)</th>
<th>Input kW, Trona Constant Speed Motor</th>
<th>MagnaDrive ASD Savings (kW)</th>
<th>MagnaDrive ASD Savings (%)</th>
<th>DOE VFD ASD Savings (kW)</th>
<th>DOE VFD ASD Savings (%)</th>
<th>MagnaDrive Savings as % of VFD Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>52.8</td>
<td>-0.4</td>
<td>-0.8%</td>
<td>-0.3</td>
<td>-0.5%</td>
<td>--</td>
</tr>
<tr>
<td>75</td>
<td>46.0</td>
<td>10.2</td>
<td>22.2%</td>
<td>20.4</td>
<td>44.3%</td>
<td>50.3%</td>
</tr>
<tr>
<td>50</td>
<td>39.2</td>
<td>15.2</td>
<td>38.7%</td>
<td>26.8</td>
<td>68.4%</td>
<td>56.6%</td>
</tr>
</tbody>
</table>

**Discussion**

Table 1 presents a summary of the results of the data analysis comparing the energy savings achieved by the MagnaDrive ASD system tested to savings derived from DOE published savings achieved by a VFD ASD system for a similar test. A review of the results presented in Table 1 shows that the MagnaDrive ASD system provides significant electrical demand (kW) savings of approximately 22% at 75% of full flow and approximately 39% at 50% of full flow. The tabulation also shows that a VFD system of similar size would provide higher savings of approximately 44% at 75% of full flow and 68% at 50% of full flow.

MagnaDrive kW demand savings were in the general range of 50-60% of the savings provided by the VFD system under similar conditions.

Compared to the VFD system the smaller savings associated with the MagnaDrive system indicates larger losses are being incurred. Table 1 shows the VFD system at a 50% flow rate saves 26.8 kW compared to savings of 15.2 kW for the MagnaDrive system, a difference of 11.6 kW. Because the control valve is fully open and the pump flow rate is the same, the 11.6 kW represents additional losses associated with the MagnaDrive system. In the MagnaDrive system losses are incurred in the conductor disk. These losses are directly proportional to the slip and the load power being transmitted. In this example 11.6 kW is power is dissipated as heat in the motor driven conductor assembly potentially causing overheating problems unless adequate cooling is accounted for in the design. This is not considered to be a serious problem for the MagnaDrive design because reviews of information obtained on previous MagnaDrive installations found no reports of problems, and during the test at the Trona site no excessively hot areas on the MagnaDrive assembly were detected.

The MagnaDrive system was shown to be capable of providing substantial energy saving benefits at the Trona test facility, up to 39% at 50% flow. During the test period the system demonstrated reliable and trouble free operation, meeting the operational requirements of the plant operation.

While the data indicates the VFD system would provide higher savings than the MagnaDrive ASD, the voltage level for the motors under consideration for the MagnaDrive ASD installations at the Trona site (4,160 V) is outside the primary range of VFD applications (up to 690 V) and would require a more costly and less available VFD design, tending to negate the benefits of VFD's energy savings potential.
MagnaDrive Corporation has developed methodologies for identifying life cycle savings factors, including energy savings, maintenance savings, reliability benefits, and other operational benefits depending on the plant site operating parameters and needs, which could be accessed by Searles Valley Minerals if desired in order to obtain more specific cost effectiveness information applicable to operations at the Trona site. It is recommended further work be done to obtain more detailed MagnaDrive ASD cost effectiveness data specific to the annual run time and duty cycle operations at the Trona site.

In general, the electronically controlled VFD adjustable speed control system provides higher energy savings at lower initial cost for low voltage applications, and would be a logical choice for these applications. For many other applications where larger, medium voltage systems are in place, the MagnaDrive may have a cost advantage over the electronic VFD system that overcomes its less substantial energy savings potential. Also, in applications where shaft misalignment, shock starts, vibration, harmonic distortions, and the VFD controller's need for a clean, dry operating environment are issues, the MagnaDrive unit may have significant cost and/or operating advantages.

MagnaDrive and Competing ASD Technologies

Description of Competing ASD Technologies

The MagnaDrive system is a magnetically coupled adjustable speed drive (MC-ASD). Any coupling that uses eddy currents induced by a magnetic field (from either permanent magnets or electromagnets) to transfer torque from motor shaft to load is a MC-ASD. There are two distinct applications of the MC-ASD technology, a fixed magnet coupling (MagnaDrive) and an eddy current (electromagnetic) coupling.

In both the MagnaDrive system and the eddy current drive system, the motor speed is constant and the load speed is varied by means of a magnetic coupling that provides variable speed.

In the case of the MagnaDrive system, the load speed and strength of the magnetic field is varied by changing the gap between the motor conductor disk and the permanent magnetic rotor on the load shaft. In the case of an eddy current clutch the air gap between the motor driven conductor and the electromagnet coil on the load rotor is constant and the speed is varied by varying the excitation of the electromagnet. The eddy current drive system requires a source of power to provide the excitation, but it requires only about 0.5% of the drive's rated power.
**Comparison of Magnetically Coupled ASD Technologies**

**MagnaDrive System (Permanent Magnet)**

Web Site: [www.magnadrive.com](http://www.magnadrive.com)

Size: 10 HP to 4,000 HP

Motor Input Voltage: No requirements or limits. The MagnaDrive ASD system does not include the motor. The drive is designed to mount directly to the existing motor shaft.

Auxiliary Power: There is no electrical power source needed to generate the magnetic field, but a 120V supply is required to provide power for the actuator.

Load Connection: The MagnaDrive coupling is installed mechanically between the motor output shaft and the load shaft.

**Eddy Current Drive Systems (Electromagnet)**

Two leading U.S. providers of eddy current drive systems were selected for review, Coyote Electronics Inc. and Drive Source International Inc.

1. **Coyote Electronics, PAYBACK ASD System**

   Web Site: [www.coyoteinc.com](http://www.coyoteinc.com)

   Size: 3 HP to 250 HP

   Motor Input Voltage: No requirements or limits. The PAYBACK ASD system does not include the motor. The drive is designed to mount directly to the existing motor shaft.

   Auxiliary Power: A 120V supply is required to provide power for the controller and to generate the magnetic field and control electronics.

   Load Connection: The PAYBACK coupling output shaft connects to the load by means of a belt drive configuration.

2. **Drive Source International, Eddy Current Drive Systems**

   Web Site: [www.drivesourceusa.com](http://www.drivesourceusa.com)

   Size: 1 HP to 200 HP

   Motor Input Voltage: Up to 480V. The motor and eddy current clutch are designed as an integral unit.

   Auxiliary Power: The controller can use a 120V circuit or a motor winding source to provide power for the controller and to generate the magnetic field.

   Load Connection: The load is connected directly to the output shaft of the integral motor/eddy current clutch unit.
RECOMMENDED MAGNETICALLY COUPLED ASD APPLICATIONS

As discussed in this report, the electronic VFD systems are generally the most frequent choice for applications at voltages below 690 V because of cost and efficiency considerations. However, there are cases where the magnetically coupled ASDs have an advantage, such as applications where vibration, power quality, harsh operating conditions, and maintenance requirements are issues. These cases must be evaluated individually to determine whether the advantages of the magnetically coupled ASDs overcome the cost and efficiency characteristics of the VFD.

The efficiency of the MagnaDrive ASD and the Coyote Electronics PAYBACK ASD system were found to be comparable in laboratory tests. Efficiency values for the Drive Source International, Inc. systems were not available, but would be expected to be in the general range of the other magnetically coupled ASDs. The MagnaDrive system is the only magnetically coupled system available in sizes above 250 horse power, and would be the sole magnetically coupled ASD for those higher horsepower applications.

CONCLUSION

Compared to the constant speed system, the MagnaDrive system was shown to be capable of providing substantial kW demand savings at the Trona test facility, about 39% at a 50% pump flow rate and 22% at a 75% pump flow rate. However, these kW demand savings were lower than the VFD results, and were in the general range of 50-60% of the savings provided by the VFD system under similar conditions.

The smaller savings associated with the MagnaDrive system indicates larger losses are being incurred than for the VFD system, potentially causing overheating problems unless accounted for in the design. However, information obtained on previous MagnaDrive installations found no reports of problems, and during the test at the Trona site no excessively hot areas on the MagnaDrive assembly were detected.

During the test period the system demonstrated reliable and trouble free operation, meeting the operational requirements of the plant operation.

While the data indicates the VFD system would provide higher savings than the MagnaDrive ASD, the voltage level for the motors under consideration for the MagnaDrive ASD installations at the Trona site (4,160V) is outside the primary range of VFD applications (up to 690V) and would require a more costly and less available VFD design, tending to negate the benefits of VFD’s energy savings potential.

It is recommended further work be done to obtain more detailed MagnaDrive ASD cost effectiveness data specific to the annual run time and duty cycle operations at the Trona site.

Other magnetically coupled ASD technologies competing with the MagnaDrive system were reviewed. Although VFD systems are less expensive and more efficient at voltages less than 690V, these other magnetically coupled ASD technologies offer similar vibration, misalignment, operating environment, and power quality benefits over VFD systems that the MagnaDrive ASD offers. However, these technologies are not produced in sizes over
250 horsepower and the MagnaDrive system would be the sole magnetically coupled ASD option for those higher horsepower applications.

In general, the MagnaDrive ASD should be considered for applications where the system voltage is above 690V, and for systems below 690V where shaft misalignment, shock starts, vibration, power quality, and the VFD controller's need for a clean dry operating environment are issues.

REFERENCES

