RONK NOTES

Installation and application of Phase Converters on Submersible Pump Motors

The phase converter and the four or six inch submersible pump motor have been quite successfully applied to rural single phase lines for many years. It is necessary to recognize the special characteristics of the submersible pump motor and also the characteristics that are encountered whenever this motor is operated from a phase converter. These characteristics must be considered in determining the proper size of phase converter for the submersible pump motor.

The lack of water in rural America is a problem and will become even more so in the future as rural America expands. One method of obtaining large quantities of water, with minimum equipment investment, is by using the submersible pump. Submersible pump motors are manufactured in a single phase design – normally through 7 ½ HP. The requirements of many installations in our rural areas require submersible pump motors that exceed the 7 ½ HP size and these are only available in 3-phase design. The problem, still being, is that 3-phase lines are not readily available throughout our rural electric network and construction costs for these lines can exceed $ 30,000 per mile. Extension of 3-phase for an individual submersible pump load is, in many instances, not economical. If single-phase power exists at or near the potential submersible pump installation, it is possible to operate the larger 3-phase submersible pump motor from single-phase through the use of a static or rotary phase converter. This would be a very economical solution to the problem.

THE 3-PHASE SUBMERSIBLE PUMP MOTOR

The submersible pump motor is a very special unit. They are normally manufactured in diameters of four or six inches. They are, by necessity, sealed from the fluid that surrounds them. The diameter limit means that the motor must be lengthened in order to build an increased horsepower rating. The long slender design results in potential vibration problems which are not normally encounters in above ground motors. The motor being installed in the fluid affords the motor a constant ambient temperature and also the flow across the unit aids the motor in cooling.

These motors do not follow standard full load current ratings which apply to equivalent above ground motors of the same horsepower and speed. The submersible pump motors will have a "maximum current rating" which includes the service factor amps of the motor and it can be expected the motor may operate near this maximum rating.

EXAMPLES

ABOVE GROUND MOTOR	SUBMERISBLE PUMP MOTOR
10 HP – 230 volt – 3 phase – 26.8 amps	10 HP – 230 volt – 3 phase – 36.0 amps
15 HP – 230 volt – 3 phase – 39.2 amps	15 HP – 230 volt – 3 phase – 51.0 amps

Once being aware of the increased full load ampere and service factor rating of the submersible pump motor, it does indicate that the installation must be evaluated different that the above ground motor installation of the equivalent horsepower. Wire sizes will be greater and the KVA requirement will also be increased. The submersible pump motor manufacturer furnishes a chart indicating the proper size of wire that must be used for the specific motor. These recommendations should be followed exactly.

Applying these motors to solid 3-phase lines result in installation procedures normally not considered in about ground motor installations. The motor phase current balance to the 3-phase submersible pump motor is critical (phase currents should normally be balanced within 5%).

Open Wye or Open Delta 3-phase services are not normally recommended for submersible pump applications. When they must be used it is recommended the next size larger horsepower motor and next larger size conductor be used on these applications.

One must also keep in mind that the submersible pump motor stands a very chance of being applied to a load which will cause the motor to operate near the service factor amps of that motor.

The fore mentioned facts affect the installation of the submersible pump motor on the 3-phase line and likewise have an effect on applying a phase converter to the same application. The Phase converter, static or rotary, must be properly sized to the maximum ampere rating of the submersible pump motor. Some phase converters have specific sizes for submersible pumps while others recommend the next larger size of converter to be used on the submersible pump motor application.

STATIC PHASE CONVERTERS

Static phase converters are normally manufactured in two styles. They are the straight capacitor design or in the autotransformer-capacitor type design. The straight capacitor is not recommended for the submersible pump motor. The autotransformer-capacitor type should be used.

The autotransformer- capacitor design is the unit most commonly applied to the submersible pump application. This time and field proven device is capable of operating a 3-phase motor at 100% rated horsepower on a single phase line. The unit consists of an autotransformer, running capacitors, starting capacitors and a contactor to take the starting capacitors out of the circuit after the motor is up to speed.

Sales Information: 1-800-221-7665 RONK ELECTRICAL INDUSTRIES, INC. Service & Support: 1-217-563-8333

106 E. State Street • Nokomis, Illinois 62075 www.ronkelectrical.com Phone: 217-563-8333 • Fax: 217-563-8336

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The autotransformer-capacitor phase converter must be sized properly to obtain satisfactory operation of the 3-phase submersible pump motor on the single-phase line. The maximum ampere rating of the submersible pump motor determines the size of converter required. This maximum ampere rating should be compared to standard above ground full load ampere charts of 3-phase motors to determine the equivalent size of phase converter required. Some manufacturers of this type phase converter have specific types recommended for submersible pump motors.

The submersible pump motor is and has been a common and successful application for the autotransformer – capacitor phase converter for 40 years. It has been widely applied throughout North American. Submersible pump motors normally have a high power factor, in the vicinity of 80-90%, and this results in the use of higher transformer taps on the autotransformer in this type converter. The phase currents can be adjusted well within the 5% current balance required.

This type converter has excellent power line characteristics. The full load single-phase power factor, with the motor operating, will be near unity or slightly leading depending upon line characteristics, the load, the length and size of conductor between the converter and the motor. The starting current will be 2 ½- 3 times the full load rating of the converter on the single-phase line and the power factor will be leading during starting. Submersible pump motors normally start in less than one second from this type of converter. Any submersible pump motor operating continuously, such as open discharge, can be operated with excellent motor phase current balance.

The phase currents should be checked carefully and the necessary steps taken to bring the motor and converter into an acceptable balance. This may necessitate adding or removing capacitors or adjusting the transformer tap of the converter for best balance.

The main disadvantage of applying the submersible pump motor to the autotransformer-capacitor style converter is that current balance can be achieved at only one point. If there is a wild fluctuation to the load on which the submersible pump motor is applied, the phase currents will go out of balance.

The autotransformer- capacitor phase converter can be manufactured with a very unique feature. It can be designed to operate a 460 volt 3 –phase submersible pump motor from either a 230 or 460 volt single-phase line. This feature will result in considerable savings during installation, particularly if 230 volt single-phase only is available to a deep set submersible pump motors. Use of the 460 volt 3-phase motor on the 230 volt single-phase systems will result in much smaller wire size and a smaller pump control than would be used on the 230 volt 3-phase installation from the 230 volt single-phase line.

INSTALLATION CONSIDERATIONS

The single – phase electrical service to the autotransformer- capacitor converter should follow standard wiring practices for the single-phase full load ampere rating of the converter. This should consist of a single phase safety switch or circuit breaker as the converter disconnect and the proper size and type of wire. The wiring from the phase converter to the submersible pump motor should follow the 3-phase recommendation as specified by the submersible pump motors manufacturer. Specifications with respect to the size of motor starter, overload protection and the size of conductors for the depth of the pump setting should be clarified with the pump manufacturer.

The autotransformer- capacitor style converter has very low power consumption wherever the motor is not operating. The core and copper loss of the autotransformer are the only losses. For example, a 15 hp unit would dissipate about 60 watts.

The starting capacitors utilized in this type of converter furnish approximately 150% starting torque to the submersible pump motor. This starting torque is normally sufficient for the application.

ROTARY PHASE CONVERTERS

Rotary phase converters are manufactured in two types. They are the non-adjustable rotary transformer and the adjustable rotary transformer designs. Both units have been successfully applied to 3 – phase submersible pump motors on single-phase lines. Either the non-adjustable or adjustable type rotary converters consist of a rotary transformer (aka: motor) and one or more capacitor banks.

The non-adjustable rotary converter has limited control of the motor phase currents. It is somewhat possible to adjust the phase currents by varying the amount of capacitance in the circuit; however, only moderate success is achieved in this procedure. In many cases it is not possible to obtain current balances within the 5% tolerance recommended for submersible pump motors.

The adjustable rotary converter does enable the installer to adjust the phase currents to within the 5% recommendation. This is accomplished by adjusting the rotary transformer taps and varying the amount of capacitance for a proper phase balance. This gives a distinct advantage in that the phase currents will hold less unbalance over the load range of the submersible pump motor. As such, mechanical motor vibrations caused by negative sequence currents will be minimized.

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INSTALLATION CONSIDERATIONS

The properly installed rotary converter on a submersible pump should have a single-phase safety switch or circuit breaker and a magnetic contactor ahead of the converter. The output of the converter should follow the submersible pump motor manufacturers specifications with respect to size of the starter, overload protection, and size of the conductor for the depth of the pump setting.

Rotary converters develop very low starting torques and on any submersible pump application that might require high starting torque, it may be necessary to add a starting panel to the installation. If the starting panel is needed it should be connected to the load side of the magnetic starter. The starting panel, when wired in at this point, will get the motor up to speed in 2 or 3 seconds and automatically disconnect itself from the circuit when the motor reaches full speed.

CONCLUSIONS

It is possible to successfully operate the 3-phase submersible pump motor on a single-phase line through the use of either a static or rotary phase converter. Proper installations can be only achieved if the recommendations and specifications of both the Phase converter and Submersible pump motor manufacturers are followed.

1. Follow the pump motors manufacturers specifications with regard to wire size and motor protection for the particular installation.

2. Use the "maximum ampere rating" of the submersible pump motor to establish the size of phase converter that will be required.

3. Use the single-phase full load current of the phase converter nameplate to establish proper single-phase wire size, fusing and disconnect means.

4. Follow the phase converter installation instructions.

5. Follow the balancing procedures outlined for the static or rotary phase converter to obtain the best possible motor phase current and the load being balanced.

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