



## Variable Speed Drives – Inverters, Soft Starters, Guidelines for Submersible Motors

All Sterling Pumps wet wound rewindable submersible motors with PE+PA windings are suitable for use with Variable Speed Drives (VSD). These devices can also be referred to as Variable Frequency Drives (VFD), Inverter Drives and Drives. Motors are also suitable for use with Soft Starters (SS).

A VSD consists of a rectifier and an inverter. The inverter runs on constant frequency. It uses PWM (Pulse Width Modulation) to generate a sine wave and regulate the output voltage. The VSD modulates both the frequency and voltage using PWM to keep the frequency ratio constant for the motor.

Sterling Pumps submersible motors are not a stated Inverter Duty motor as per some country regulations, however they can be used with VSD's without issue providing the guidelines below are followed.

### Pump Load

The pump load should not exceed the motors nameplate amps, voltage and frequency.

### Frequency

Maximum frequency - the maximum working frequency should never exceed the nominal frequency of the motor. Either 50 Hz or 60Hz.

Minimum frequency - is 30 hertz. The minimum frequency should also be taken into account relating to motor cooling and velocity of water flow over the submersible motor. The motor speed/frequency must always guarantee the minimum cooling velocity.

### Motor Cooling - Minimum Velocity

The speed (hertz) must always ensure the minimum cooling velocity over the motor is always available. Minimum velocity for a 6" motor is 0.15 m/s. Refer to motor data sheets for velocities required. The velocity can be calculated from the flow rates required, the bore casing ID and the motor OD.

### Starting

The starting ramp time should be approximately 3 to 4 seconds from starting to reaching the minimum frequency of 30Hz. From 30Hz up to 50Hz there is no time limit as long as the pump is delivering the minimum cooling velocity over the motor.

The number of starts per hour should not be exceeded. Refer to the motor data sheets for maximum number of starts. The motor must always have at least 1 min between starts to allow the windings to cool down. (if no data sheet, use 15 as the maximum number of starts)

If available in the drive settings, turn on 'torque boost'.  
The maximum number of frequency variations in one minute is '8'

### Stopping

Stopping the motor can be achieved in two ways;

1. Taking away the power source and allowing the motor inertia to slow and stop the motor, also known as a 'coasting' stop.
2. Setting a ramp down time, at 30 Hz ramp down between 3-4 seconds to a full stop. From 50Hz down to 30Hz there is no time limit as long as the pump is delivering the minimum cooling velocity over the motor.

If possible, set up switching frequency on the values between 3 and 5 kHz.

### Filters

Sine filters / Output filters (LC-Sinus or RC filters) are required when operating submersible motors on VSD's to limit voltage peaks (U<sub>peak</sub>) and to reduce the dU/dt (or dV/dt) which cause stress on the insulation of the submersible motor. Some VSD's have inbuilt filters, check with your VSD supplier or panel builder to ensure they comply to these requirements.

Sine filters are recommended when; 1) voltage is over 380V 50Hz. 2) Cable run is 20 metres or greater. 3) dV/dt is more than 500 V/μs. 4) U<sub>peak</sub> exceeds 850V.

Voltage rise/time (dV/dt) filters, limit the peak voltage to 1000V and keep the time rise greater than 2 μsec, also referred to as dV/dt < 500V/μsec. Traditional dV/dt filters are not effective in the protection of submersible motors.

Cable lengths ≤ 20M			
Insulation	Filter	U <sub>peak</sub> Max.	Max. dV/dt
PE+PA	None	850V	500 V/μs

Cable lengths ≥ 20M			
Insulation	Filter	U <sub>peak</sub> Max.	Max. dV/dt
PE+PA	Sine wave	850V	500 V/μs

V/μs - Volts per micro second

#### **Temperature Protection**

The method of monitoring the winding temperature of the submersible motor can be via a Pt100 installed into the motor with a suitable length and sized cable up to the surface control enclosure.

#### **Overloads**

Submersible motors should utilise a Class 10 or similar overload protection device or setting. The protection must trip within 10 seconds at 5 times full load current/amps (FLC or FLA) in any line and also trip within a maximum of 115% of nameplate maximum amps in any line.

#### **Drop Cable Sizing**

When Sine/Output filters are fitted, be aware that there is a voltage drop through the filter which can be as high as 5% depending on the type/make of filter used/recommended by the VSD supplier. This voltage drop must be taken into account as a part of the total voltage drop calculations as the maximum permissible voltage drop according to AS/NZ 3008 is 5%.

#### **Transducer**

Should transducers be installed in the system, they should be placed away from pipe bends, other connections that could create turbulence or formation of air that may give incorrect readings.

### **Soft Starter**

#### **Starting and Stopping**

The Starting ramp time should be a maximum 5 seconds.

The Stopping ramp time should be a maximum 5 seconds or coast to stop.

#### **Temperature Protection and Overloads**

Same as for VFD.

These guidelines refer to 3 phase submersible motors, not applicable to 230/240V single phase.