#

# NATURAL RESOURCES CONSERVATION SERVICE

# Specifications for Construction and Materials

Pumping Plant - Variable Frequency Drives (VFD)

Code 533

# 1. General

### 1.1 Scope of Work

The contractor shall furnish, and install a pump control system designed to operate one pump using Variable Frequency Drives (VFDs) as described herein. The control system shall be designed utilizing proven technology in control design for constant pressure, constant flow rate, or a combination of flow and pressure ranges to provide the desired operating conditions of the pumping system. The control system shall be operator and maintenance friendly to ensure ease of system set up and to limit down time.

The pump control system shall be capable of operating one electric pump motor as manufactured by \_\_\_Goulds\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
| Model: | 11 CHC |
| Horsepower: | 50 HP  |
| Full-load amps (FLA): |  |
| Incoming power shall be: |  | VAC |  | Phase, 60Hz |
| Line/load reactor required by electric supplier? |  |  |  | No |

The desired operating ranges for pump output pressures and flow-rates are:

|  |  |
| --- | --- |
| Minimum Pressure (psi): | 35 |
| Maximum Pressure (psi): | 50 |
| Minimum Flow (gpm): | 400 |
| Maximum Flow (gpm): | 975 |

The control system shall use a pressure transmitter and/or flow meter connected to the discharge piping of the pump.

The factory assembled system shall include:

 -Variable Frequency Drive

 -VFD protection package

 -Line and load reactor as required

 -Lightning arrestors

 -Pressure transmitter or flow meter

 -Enclosure

 -Main disconnect

 -Circuit breaker

 -Alarm and Communication interface

# 2. Products:

### 2.1 General

2.1.1 Codes

Electrical equipment, materials and workmanship shall comply with all applicable codes, safety and fire law regulations at the location of the work and shall conform to applicable codes and standards of the organizations listed below.

1. National Electric Code (NEC)

2. National Electrical Manufacturers Association (NEMA)

3. American National Standards Institute (ANSI)

4. Underwriters Laboratories (UL 508)

5. International Electrotechnical Commission (IEC)

2.1.2 Component Standards

All equipment and materials shall be new and shall bear the manufacturer’s name and trade name. In cases where a standard has been established for the particular material, the material shall be so labeled. The equipment to be furnished shall essentially be the standard product of a manufacturer regularly engaged in the production of the required type of equipment for this type of work and shall be the manufacturers latest approved design.

### 2.2 Construction

2.2.1 Enclosure

**For indoor applications:**

Indoor applications are defined as a VFD control panel mounted in a clean, insulated, temperature-controlled environment. In such applications, the described equipment shall be housed in a single NEMA 12 powder-coated steel enclosure of a wall thickness of not less than 0.075in. The enclosure shall be sized accordingly to allow easy access to components and provide adequate ventilation for VFDs. The enclosure shall also include louvers, filter fans, and/or air conditioning as required from VFD heat loss calculations and average ambient temperatures. All louvers, filter fans, and air conditioning units shall conform to appropriate NEMA and UL standards and must be mounted directly to the VFD control panel. Direct exposure of the VFD unit to un-filtered, outside air is not acceptable. Ventilation or cooling shall be adequate to ensure that the VFD does not operate above its rated ambient temperature rating.

**For outdoor applications:**

Depending on the design of the VFD unit, the described equipment shall be housed in one of two types when installed in outdoor applications.

VFD with external heat sinks

VFD units with external heat sinks that are designed to be flange-mounted on the exterior of a cabinet may be mounted in such a fashion. A dust-tight, flanged-mounted seal shall be maintained, and a NEMA 3R rated rain hood shall protect the external heat sinks. The mounting cabinet shall be a single NEMA 3R or NEMA 4 free standing, power-coated steel enclosure of a wall thickness of not less than 0.075in. The enclosure shall be sized accordingly to allow easy access to components and provide adequate ventilation for the VFD. The enclosure may also include louvers and filter fans as required from heat loss calculations and average ambient temperatures. All louvers and filter fans shall conform to appropriate NEMA 3R or NEMA 4 or UL Type 3 or UL type 4 standards. Direct exposure of the VFD unit to un-filtered, outside air is not acceptable. Sun shielding of the enclosure shall be provided for on-site.

#### VFD without external heat sinks

The described equipment shall be housed in a single NEMA 4 free standing, powder-coated steel enclosure of a wall thickness of not less than 0.075in. The enclosure shall be sized accordingly to allow easy access to components and provide adequate ventilation for the VFD. The enclosure shall include water/air heat exchangers, glycol/water heat exchangers, or air conditioners as required from VFD heat loss calculations and average ambient temperatures. Additional measures such as painting the enclosure white, installing a sun shield, and adding insulation to the inside of the enclosure shall also be considered as to prevent the temperature inside the enclosure from exceeding the acceptable VFD temperature limits. All components used, or modifications made, to the enclosure to aid in cooling must conform to NEMA 4 and applicable UL standards.

**Air Conditioning**:

Should air conditioning be required to properly cool the VFD control panel, the cooling output of the A/C unit must be controlled to ensure that the following conditions do not occur: overcooling of the VFD panel, freeze-up of the A/C compressor loop or excessive cycling of the A/C compressor. The A/C unit must be sized and rated to accommodate all environmental conditions including high and low temperature extremes, rodents, dust, etc.

### 2.3 Control Circuit Wiring

Control circuit wiring inside the panel shall be 18 gauge (AWG) minimum, type MTW or THW, rated for 600 volts. All power wiring shall be 12 gauge (AWG) minimum rated for 600 volts. Conductors shall be color-coded using the same colors throughout the entire panel. Control circuit wiring shall be organized in snap-cover raceways. All wires shall be individually numbered or labeled at both ends. All wiring shall be done in a workman-like manner.

### 2.4 Schematics and Labeling

As per UL and the NEC, all power input and output points of connection shall be clearly labeled. A detailed color schematic showing all control and power circuits shall be affixed to the inside of the panel door. In addition, a label displaying pre-programmed factory settings such as pressure set point shall be affixed to the inside of the panel door.

### 2.5 Safety

Control panel construction methods shall take into account provisions to ensure operator safety from electrocution. UL508A safety standards shall be observed. In addition, all terminals on power circuits carrying greater than 50V shall be made finger-safe if this provision does not already exist in the original component manufacturer’s design. This provision may be accomplished with the addition of appropriate safety shields over exposed terminals.

# 3. Components

### 3.1 Variable Frequency Drive

A variable torque Variable Frequency Drive (VFD), of the pulse width modulated type shall be mounted inside the enclosure. The VFD shall monitor the sensor (pressure or flow rate) signal (4-20mA loop powered signal) and control the pump speed using the factory pre-programmed control points in order to maintain the desired operating condition. The VFD shall also be capable of having an acceleration or deceleration time, adjustable 3 to 1800 seconds with override circuit to prevent nuisance trips if the deceleration time is set too short.

The VFD shall be sized to the pump motor supplied by the Contractor or the existing pump and it shall be compatible with all equipment utilized at the pump station. The VFD’s shall meet the following requirements:

# Analog input

The VFD shall come standard with a 4-20mA input channel. The input signal shall be scalable from 0.0 to 999.9 and the displayed unit shall be selectable from: pressure, flow, and/or percent. The controller shall detect invalid sensor readings and open loop circuit and display a fault message. The analog input channel shall have a 0.1% resolution and incorporate noise filtering.

 Sizing / Efficiency

* The VFD shall be sized to the motor Service Factor Amps (SFA) and not the Full Load Amps (FLA) for deep submersible well pumps.
* The efficiency rating shall be of 95% or better across the full operating speed range.
* Each VFD shall account for all motor service factors, have a guaranteed ability to provide continuous output amperage of 15% greater than the maximum amperage required by the motor at a specified input voltage and have an overload current capacity of 120% for 1 minute.

 Service Conditions

The VFD shall be designed to operate within the following service and environmental conditions:

* 100% performance rating in the temperature range 0-40° Celsius. Cooling shall be provided if expected operating temperatures exceed 40° Celsius.
* 0 to 95% relative humidity, non-condensing
* Elevation to \_1300\_\_\_ feet (\_\_\_\_\_\_\_ meters) without derating
* AC line voltage variation, -10% to +10%

Pump / System protection:

The VFD shall have the following pump and system protection:

* Low Pressure
* High Pressure
* Low Water Input (low suction pressure/low level),
* Broken Pipe
* Loss of Prime
* Dry Well
* Feedback Loss Alarm & Pump over-Cycling

Motor / Drive protection:

The VFD shall protect the motor and the drive against the following conditions:

* Output Phase Loss
* Ground Fault
* Motor Overload
* Motor over-Temperature & Broken Shaft
* Over Voltage
* Input Phase Imbalance
* Under Voltage
* Phase Imbalance and
* Short Circuit protection.

These faults shall provide an orderly shutdown of the VFD with clear indication of the fault. The history of previous faults shall be stored in memory for future review. A automatic restart option shall be provide with a minimum 30 second time delay. This function permits automatic restarting after the drive controller detects a fault, provided that the other operating functions are correct, a run command is present, and the fault has disappeared. This shall be a function that is field selectable.

Phase conversion:

For installations where 3-phase power is not available, single-phase power shall be supplied to the VFD and the VFD shall convert the power to 3-phase. Extreme care shall be taken to properly size the VFD in phase conversion applications; it shall only be done in accordance with the manufacturer’s specifications. In all cases, a 3-phase motor shall be used.

Keypad / operation:

The VFD shall be equipped with an interface keypad with START/STOP buttons and a display for the visualization of process and alarm status. The main screen shall display the set-pressure/flow rate, the actual pressure/flow rate (in psi/gpm), the motor current (in Amps), and the motor speed in (Hz) simultaneously The keypad shall allow the user to navigate through the configuration menus and adjust set point values via the front keypad. The VFD setup shall be simple and shall not require the use of a laptop computer. The VFD shall be factory configured and tested to minimize field programming and start up time.

The VFD shall be provided with a 12-month standard warranty against defects in workmanship and materials under normal use operation and service from the date of startup.

### 3.2 Pressure transmitter

In those systems where pressure is used as the controlling factor, the pressure transmitter shall be industrial grade and have a static accuracy of 1% of full scale or better. The pressure transmitter shall be two-wire loop powered and produce a 4-20mA signal proportional to the discharge pressure and be fully temperature compensated. No calibration of the transducer shall be required in the field. The connection shall be mounted vertically and in such a manner as to minimize the possibility of air accumulation between the transmitter and the discharge pipe.

### 3.3 Flow meter

In those systems where flow rate is used as the controlling factor, the flow meter shall be industrial grade and have a static accuracy of 3% of full scale or better. The flow meter shall produce a 4-20mA output signal proportional to the discharge. No calibration of the flow meter shall be required in the field. The flow meter shall be connected to the pump discharge. Flow meter shall have an external power source that provides a consistent power supply.

### 3.4 Communication

The control panel shall be capable of communicating to a central monitoring system via RS 232 or RS 485 port using MODBUS protocol.

### 3.5 Circuit Breakers

All electrical circuits shall be protected by molded case circuit breakers. Each pole of the breaker shall provide inverse time delay overload protection and instantaneous short circuit protection by means of a thermal magnetic element.

The breaker shall be operated by a toggle-type or rotary handle and shall have a quick make, quick break switching mechanism that is mechanically trip free from the handle. Tripping due to overload or short circuit shall be clearly indicated by the handle automatically assuming a position midway between the manual “on” and “off” position. Breakers shall be completely enclosed in a molded case and shall bear the UL label. The short circuit interrupt capability shall exceed the fault level (Isc) of the incoming power. The circuit breakers for the VFDs shall be mounted on the sub-panel of the enclosure with the operating handles mounted through the door and capable of being locked in the OFF position. The handles will interlock with the door mechanism, only allowing the door to open when the breakers are in the OFF position.

### 3.6 Relays

Relay contacts shall be rated for 10 amps at 300VAC. Relay sockets shall have screw terminals with self-lifting clamps and terminal identification numbers located at each connection on the relay socket. A “Motor Running” relay and a “VFD Ready” relay shall be available for user interface.

### 3.7 VFD Protection Package

The VFD unit shall be protected from line voltage with a line isolation contactor that is interfaced with a digital voltage monitor. The digital voltage monitor shall be capable of detecting phase loss, phase reversal, phase unbalance and over/under voltage. The voltage monitor shall be wired to the line isolation contactor so that when any such conditions are detected the contactor breaks line voltage to the VFD. The line isolation contactor shall be fully rated for across-the-line starting of the motor and shall include appropriately sized overloads for the FLA of the motor.

A lightning/surge arrestor shall be provided at the incoming power terminals to the control panel outside of the panel box. The unit shall be of the solid-state type and be able to clamp in five (5) nanoseconds and absorb up to 25KA peak surge current during an occurrence. The unit shall have a surge life expectancy of 10,000 occurrences at 200 amps.

### 3.8 Line and Load Reactors:

Each VFD shall be equipped with a factory-installed swinging choke capable of reducing total harmonics distortion by up to 25%. For VFD’s not equipped with a swinging choke, a 5% impedance line reactor shall be installed ahead of each VFD to reduce the effects of current and voltage harmonics. The VFD shall be sized such that the addition of the 5% line reactor does not reduce drive performance.

The installation shall follow all NEMA cable length guidelines. If NEMA guidelines are exceeded:

1. The motor shall require a load reactor if the pump leads from the VFD exceed the following lengths:
* 800 ft for 208-240V applications
* 200 ft for 460V applications
* 50ft for 575V applications
1. The VFD shall require a dV/dt filter if the pump leads from the VFD exceed the following lengths:
* 1,500 ft for 208-240V applications
* 500 ft for 460V applications
* 200 ft for 575V applications

Individual motor manufacturers may have different standards of protection. All Load Reactors used for motor protection must be designed and implemented via the motor manufacturer’s recommendations.

### 3.9 IEEE-519 Harmonics Mitigation Hardware:

If required by the local power provider, a full IEEE-519 harmonics analysis of the VFD installation must be performed. Utilizing this analysis the VFD panel manufacturer shall determine the harmonics mitigation hardware necessary to fully comply with IEEE-519. This shall include the use of a line reactor, harmonics kit, phase-shift transformer, or other appropriate hardware approved for this application. Upon request, the VFD panel manufacturer shall make available their IEEE-519 analysis worksheet.

The appropriate harmonics mitigation hardware shall be fully integrated into the VFD control panel package such that it is deliverable to the job site in a single package and shall not require any additional on-site wiring. Additional heat loads and amp losses resulting from harmonics mitigation hardware shall be determined and appropriate steps shall be taken to ensure that the VFD control panel design accommodates these issues.

# 4. Quality Assurance

### 4.1 Manufacturer Experience

4.1.1. UL Certification

The manufacturer of the control system shall be certified by Underwriters Laboratories (UL) as being a UL 508A listed manufacturing facility and certified to install a serialized label for quality control and insurance liability considerations.

4.1.2 Experience

The manufacturer of the control system must be able to document experience in successfully designing and manufacturing similar control systems using Variable Frequency Drives in pumping applications.

### 4.2 Manufacturer Quality Control

The control system shall be functionally tested by the manufacturer and/or supplier and certified as a complete system to assure proper operation per specification.

### 4.3 Approval

All controls must have the capabilities and functions as outlined in the specifications.