

# The VS-1 Variable Speed Controller



Oil & Gas Instruments, Inc.

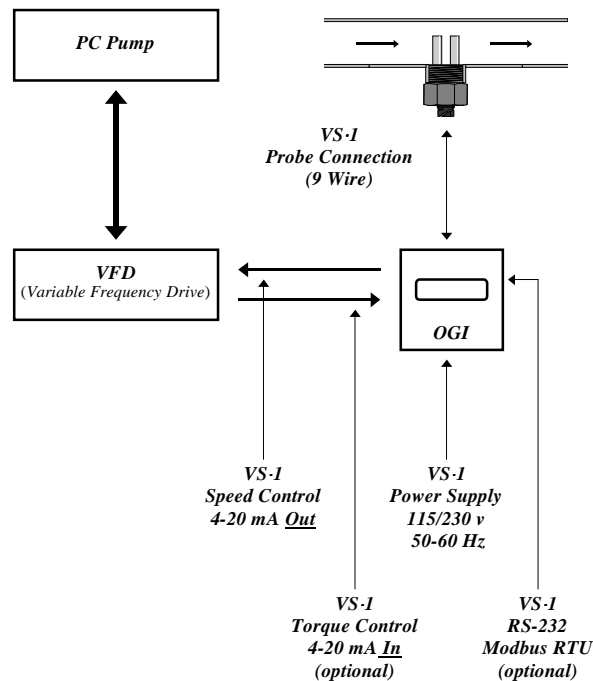
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## *Oil & Gas Instruments' VS-1 Technical Overview*

The VS-1 *Variable Speed Controller* represents the next generation in automated pump control technology, continuously fine-tuning pump speed to achieve optimal production while protecting against loss of flow through the pump. No other instrument could be designed better or be easier to use.

The VS-1 has no moving parts. Instead, it operates on a principle of thermal cooling. Both of the VS-1's stainless steel probes measure temperature. That is, each one acts independently as a separate, high-precision thermometer. In addition, one of the probes is supplied with a heating coil. When the coil is turned ON, the tip of the probe is heated. This heat is absorbed by passing fluid: the higher the flow, the more heat absorbed, and the greater the cooling at the heated tip. By comparing how the temperature at the heated probe is changing up and down relative to the unheated probe, the VS-1 can accurately measure changes in flow past its tips over time.

It is worth remarking that gas absorbs heat at a much lower rate than either oil or water. Even fast moving gas cools much less effectively than slow moving oil or water. This makes it easy to distinguish between gas and liquid in the flowline, a problem often affecting other flow measurement devices such as turbine meters and orifice plates.



### *Easy to Install*

The VS-1 probe is installed into a standard 2" NPT close to the wellhead. It is fitted with a 1" thread above a 2.5" × 1.5" hexagonal base and so plumbing requires only a pipewrench.

## VS-1 Process Control

The VS-1 is an auto-calibrating instrument. Once installed and powered on, it immediately begins controlling a well. For variable speed control, the VS-1 outputs a 4-20 mA signal to a *variable frequency drive* (VFD) which is converted into a corresponding *rpm* speed for the pump. The objective is to always operate the pump at the lowest speed required to deliver current production from a well. To find this speed, the VS-1 follows a patented process called *climb & double-back*. *Climb* refers to how speed is increased. *Double-back* refers to how speed is decreased.

The VS-1 keeps track of how the speed of the fluid column is changing with each change in pump speed. It records this information in a special table:

| <i>Pump Speed (mA)</i> | <i>Flow Rate (°C)</i> |
|------------------------|-----------------------|
| 4 mA                   | 🌡️                    |
| 5 mA                   | 🌡️                    |
| .                      | .                     |
| .                      | .                     |
| 20 mA                  | 🌡️                    |

The table illustrated in the diagram is called the VS-1's *Build Table*. The rows of the table show the speeds in increasing order. Next to each speed, a flow rate is recorded. Since the VS-1 is a thermal device, flow rates are recorded by the temperatures they register past the probe. The higher the cooling effect at the heated probe, the higher the flow rate observed.

Whenever the instrument is powered on or reset, a build of the table is automatically started. The table is built from the lowest speed upward. First, the speed is set to 4 mA, and a flow rate is recorded for 4 mA. The speed is then stepped to 5 mA, and a flow rate is recorded for 5 mA, and so on. The table is constructed to ensure that each successive increase in speed also leads to an increase in flow.

If an increase in speed does not also increase flow then the well's current production rate is below what the pump can deliver at the higher speed, and so the speed can be stepped back. If the flow rate is observed to actually drop off, the VS-1 may actually have to notch speed back several steps. To find the correct speed for the lower flow rate, the VS-1 searches back through its table, comparing the decreased flow rate against those observed at lower speeds. It selects as the new speed the lowest one in the table having a recorded flow rate above the current production rate of the well.

In this way, the exercise of building the table occurs in tandem with the process of varying pump speed. When production levels from the well rise, the VS-1 finds values for its *Build Table* while stepping up speed. When production levels fall, the VS-1 searches back through its table for the minimum speed required to capture the lower production.

## ***Bells & Whistles***

- ***Production Optimization***

A practice common at many PC (*progressing cavity*) installed wells is to carry a fluid reserve in the casing to draw down in the event inflow into the wellbore drops below what is required to maintain proper pump fillage. The weight of this fluid reserve causes hydrostatic backpressure on the formation. As a result, production is often less than what could otherwise be achieved. By varying the speed of the pump, the VS-1 maintains a constant (low) downhole fluid level while at the same time ensuring correct flow through the pump. Production increases can be dramatic: paybacks have been achieved for the VS-1 that are less than one month.

- ***Automatic Calibration***

The VS-1 calibrates itself automatically to a well and is designed to operate a pump at the lowest speed required to capture current production, thereby achieving a constant downhole fluid level. It is extremely responsive to well pump downs. Continuous pumping from the perforations reduces reservoir back pressure and optimizes production. Constant, continuous flow in the wellbore reduces sanding problems, requirements for paraffin removal, cold oil start up problems, and other downhole workover operations.

- ***Complete Pump Protection***

The VS-1 has a complete set of safety options available to protect the pump in response to well-related problems such as sanding, well pump off, gas slugs, and other problems. An optional signal input is available for limiting speed changes to within prescribed torque limits. The pump can be stopped based on conditions such as production loss and over-torque. Pump re-start can be restricted to an operator (manual re-start only) or fully automatic (based on a pre-set timer).

- ***Scale Resistant***

The VS-1 probes are constructed of stainless steel having a finely polished surface. A by-product of the heat radiated by the heating coil is to minimize the buildup of wax and other residue on the surface of the probe. In practice, both tips of the VS-1 contain heating coils, however only one is ever turned ON at a time. Periodically, the roles of the two probes are reversed: the ambient probe assumes the role of heated probe and vice versa. In this way, both are kept free of scale due to paraffin, etc. over time.

- ***Modbus RTU***

The VS-1 contains an RS-232 interface compatible with the Modbus RTU protocol for remote communication and other SCADA requirements.

## ***Technical Specifications***

- Power: 115/230v, 50-60 Hz, ½ Ampere
- Probe Temperature Operating Range: -10°C to +180°C
- Probe Dimensions: 1" Thread; 2.5" × 1.5" Hexagonal Base
- Probe (Tip) Length Above Thread: 4 cm
- NEMA-4x Rubber Gasket, Universal Key, Double-Panel Steel Enclosure
- Enclosure Dimensions: 30cm × 30cm × 15cm
- 5 Status LEDs, 4 × 40 LCD Backlit Display, 8 Command Keys
- Environmental Operating Range: -40°C to +85°C
- 4-20 mA ADC Input (Torque) Signal
- 4-20 mA DAC Output (Speed) Signal
- Solid State Relay (2 Amp, 240v AC Out)
- Modbus RTU Compatible (RS-232)
- ½ Amp SloBlo Fuse Protection
- CSA Class I, Division 2 Approved
- ISO-9001 Manufacturing

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