Pipeline Reconfiguration

Medium-Voltage Electrical System

Replacing the mainline turbine-driven crude-oil pumps with electric-driven pumps significantly changes the power requirements for the trans-Alaska pipeline pump stations. Pump Stations 1, 3, 4, and 9 will each have three new pumps driven by large electrical motors that operate at 6,300 volts (6.3 kilovolts, or kV).

Electrical engineers refer to the power at these levels as "medium voltage." Don't let the term fool you. Medium voltage means power from 1,001 to 35,000 volts — high voltage for the rest of us.

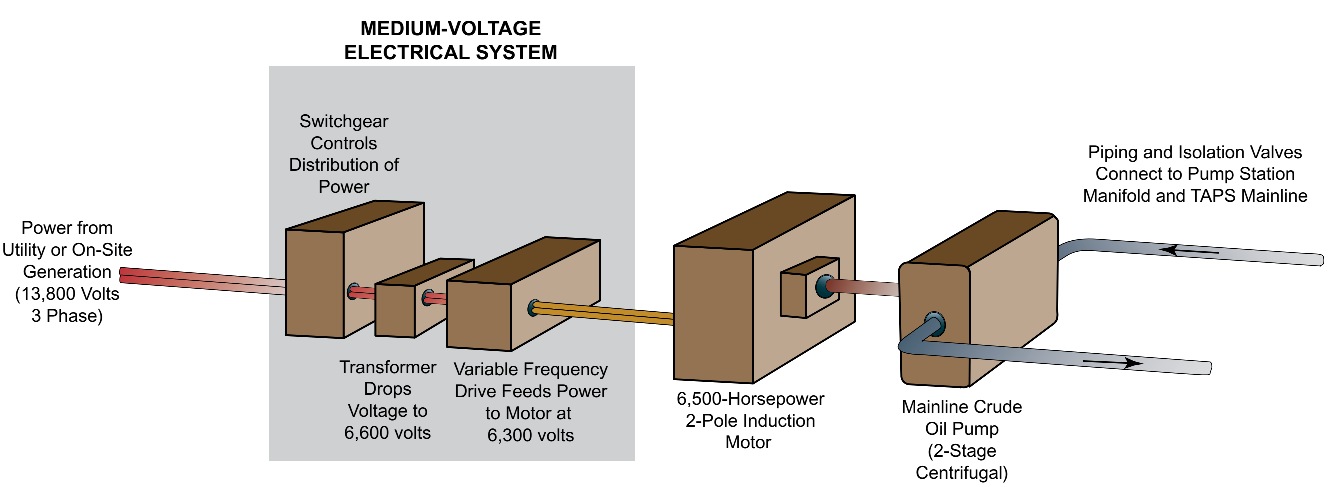
Electric power will be provided by a combination of on-site electric generators and commercial power. (Pump Stations 1 and 9 will have electric substations for connection to commercial power). Power delivered to the medium-voltage system will be at 13,800 volts.

Each pump station will have three new modules called "VFD" modules — for *variable frequency drive* — to control and distribute power. Each of the three new pump motors will be fed power from its own VFD. A VFD module has three main components:

- Switchgear to distribute the power (in two of the three modules at the pump station),
- A transformer to isolate the VFD and reduce the voltage, and
- A VFD to vary the frequency of the power to control the motor and pump speed.

This fact sheet contains diagrams and photos depicting the VFD modules and how they work. A description of the main components of the modules can be found on the back page.

Schematic of Reconfigured Pump Station



Switchgear

The photo above shows part of the ABB switchgear with the front panels open. The switchgear consists of a series of sections. The first on the left houses the control wiring for the switchgear. The section at right contains the circuit breaker and the computer (multifunction protective relay) that controls that breaker. Each VFD module will have six or seven breakers. The computer can sense the full range of current and can be programmed from a laptop computer. In addition, a communications module will interface with the PLC.

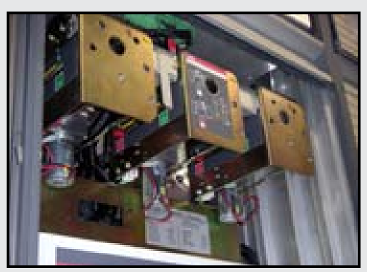
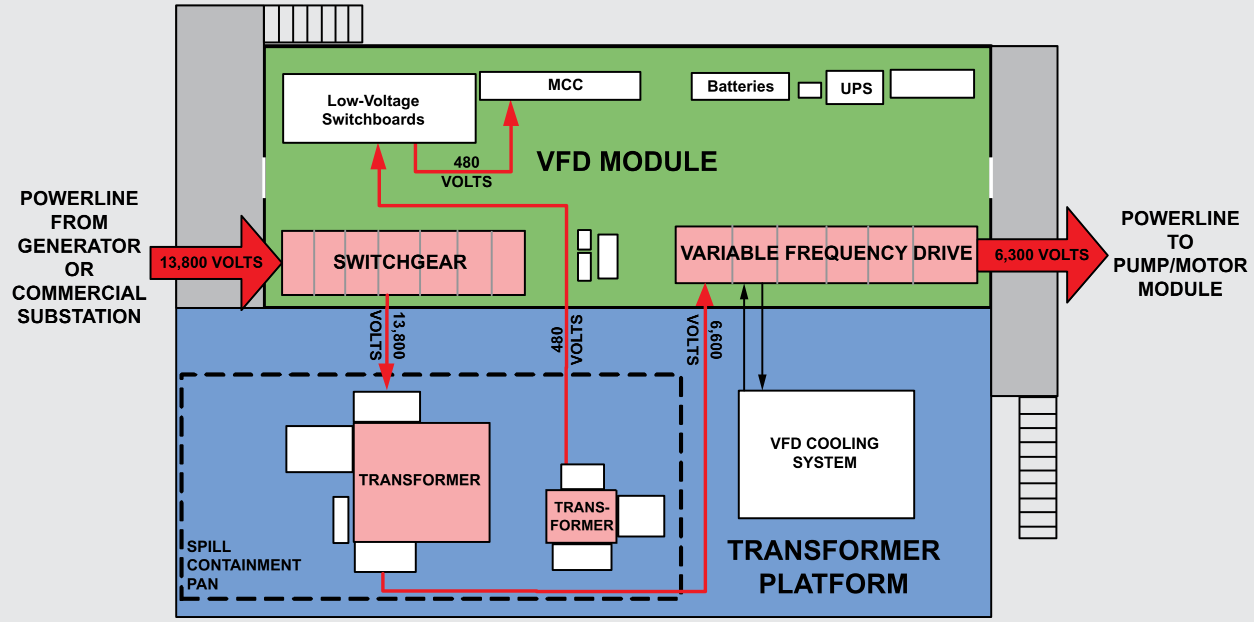


ABB Photo

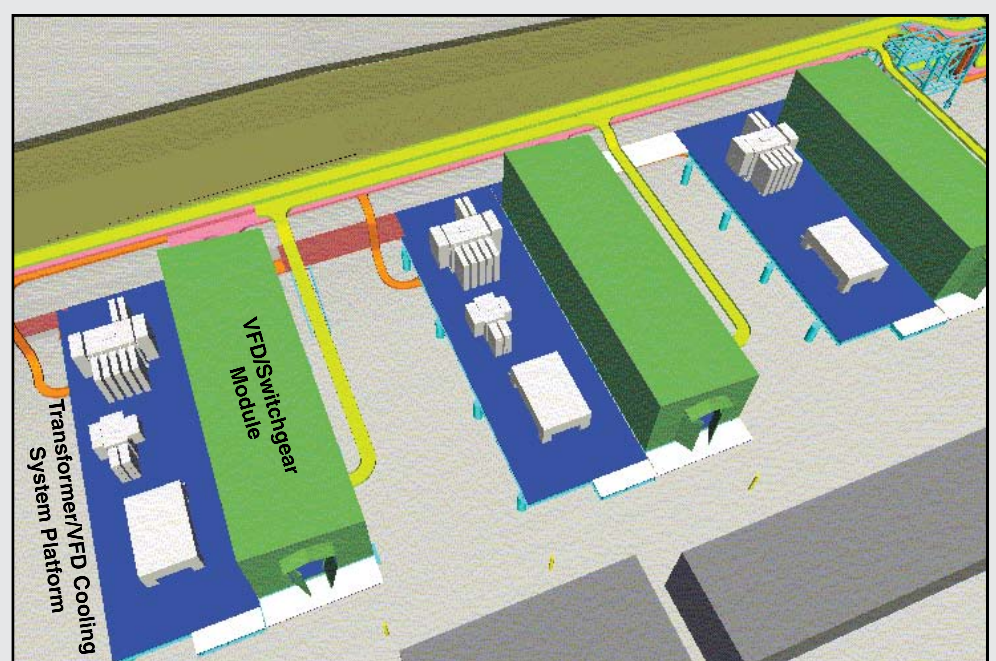
ABB Photo

The actual switching mechanism is contained in the back of the unit so that operators are never exposed to the medium-voltage components. Copper tubes (or bus) that supply the power to the circuit breakers are shown at left. The photos above show the breaker mechanism and how an operator can lock the breaker.

Anatomy of a VFD Module



Three VFD modules will be installed at Pump Stations 1, 3, 4, and 9. All three will contain VFDs, while two will also contain switchgear. A platform adjacent to the module will hold a cooling system for the liquid-cooled VFD, a transformer to step down the incoming power from 13,800 volts to 6,600 volts, and a station transformer to provide 480-volt power to the module. The VFD controls the frequency of the power in order to vary the speed of the pump motors. The photo below shows a 3-D rendering of the three VFD modules planned for Pump Station 4.



Variable Frequency Drive

The variable frequency drives (VFD) are manufactured by Allen-Bradley, and each consists of six sections. The section above at left houses the power cable terminations in the back and the controls in the front, while the next section contains the power electronics that condition the power. The other sections house capacitors, the DC link, and the pumps for the liquid cooling system. A single VFD module produces the frequency-controlled power needed to run a single mainline pump motor.

The photo at top left shows the power cable terminations, which are behind a locked panel. The power electronics are seen in the photo above, while some of the capacitors can be seen below left.

Switchgear

The switchgear serves much the same purpose as the electrical breaker panel in a house: the gear is the central distribution point for the power and provides circuit breakers to protect the power system from overloads or faults. Two of the three VFD modules at each pump station will contain switchgear to handle the 13,800 volts of incoming power.

The switchgear being installed is manufactured by ABB Power Technology Products of Ludvka, Sweden. This air-insulated switchgear has built-in functions for tripping, interlocking, alarms, operational information, maintenance needs, and arc protection. Every breaker panel contains a multifunction protective relay served by a range of sensors that give this computer the information it needs to continuously manage the switchgear.

A key feature of the ABB switchgear is an extremely fast arc eliminator. If an open arc occurs in the switchgear, all three phases are grounded so quickly that hot and poisonous arc gases don't form and dangerous pressure doesn't have time to build up. In addition, workers are protected from accidental contact with medium voltage since all primary circuits are in the unit's main circuit enclosure behind the breaker panels.

The switchgear does not have viewing windows for a worker to visually verify that disconnection has occurred when the breaker is opened. Alyeska met with the Joint Pipeline Office (JPO) and the Alaska State Electrical Inspector and agreed that the switchgear needs a visible means of disconnect to meet the National Electrical Code. Separate switches will be installed between the generators and the switchgears, on the tie between the A and B switchgear power busses, and on the feeds from each switchgear to the third VFD module.

Once the switchgear is installed in the VFD modules, an Underwriters' Laboratories (UL) inspector will field-inspect the units and certify them. Each section of the switchgear will be UL-labeled before the modules are sent to the pump stations.

Transformer

Power leaving the switchgear is still at 13,800 volts, and the voltage must be dropped to 6,600 volts for the variable frequency drive. Each VFD module will have an adjacent platform for the transformer. The transformer performs this function and isolates the VFD from the main power system.

This platform will also support a smaller transformer to provide 480-volt power for the VFD module itself. Both transformers, which contain cooling oil, will sit in a spill containment pan to protect the environment from potential spills.

Variable Frequency Drive (VFD)

The purpose of the variable frequency drive is to run the pump motors at the speed needed for pipeline flow. The VFD system, which is manufactured by Allen-Bradley of Milwaukee, Wisconsin, consists of:

- Controls and terminations for the power cables,
- Electronics to manage the power,
- Capacitors (two sections),
- DC link, and
- Pumps for the cooling system.

Because the VFD generates a lot of heat, it is liquid-cooled. The radiator for the cooling system is located next to the transformers on the platform outside the module.

Each new mainline crude pump will be driven by a 6,500-horsepower induction motor. The speed of the large electrical motors is controlled by varying the output frequency of the power supply — the function of the variable frequency drive. The speed range of the motors is 1,440 to 3,960 rpm, representing a frequency range of 24 to 66 Hz. ("Frequency" refers to the rate at which the current "alternates"; 24 Hz is 24 cycles per second.)

Typical household power is 60 Hz, but other frequencies are present on the output of the VFD; i.e., the power is not clean. You can think of the VFD unit as a large power conditioner that regulates the voltage and frequency of the power sent to the pump motors. The VFD is managed by the pump station's PLC.

From a safety standpoint, the VFDs are set up so that access to the medium-voltage components is not possible until the power to the VFDs has been de-energized. Once the circuit breaker is opened and the equipment de-energized, access procedures will require that the cable must be grounded and the energy isolated by lockout and tagout procedures. Confirmation that the equipment is safe for maintenance will then be required before access to components that carry medium voltage.