Positive Displacement Pumps Keep LPG Flowing

Milroyal C pump minimizes refinery flaring and reduces operating costs

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Petroleum refiners have historically used flares to burn off waste gases to meet product specifications. This practice is increasingly at odds with environmental regulations designed to curb greenhouse gas emissions. Recent rules enacted by the U.S. Environmental Protection Agency (EPA) to further curtail air emissions and significantly reduce flaring from refineries have placed a greater sense of urgency on developing new solutions.

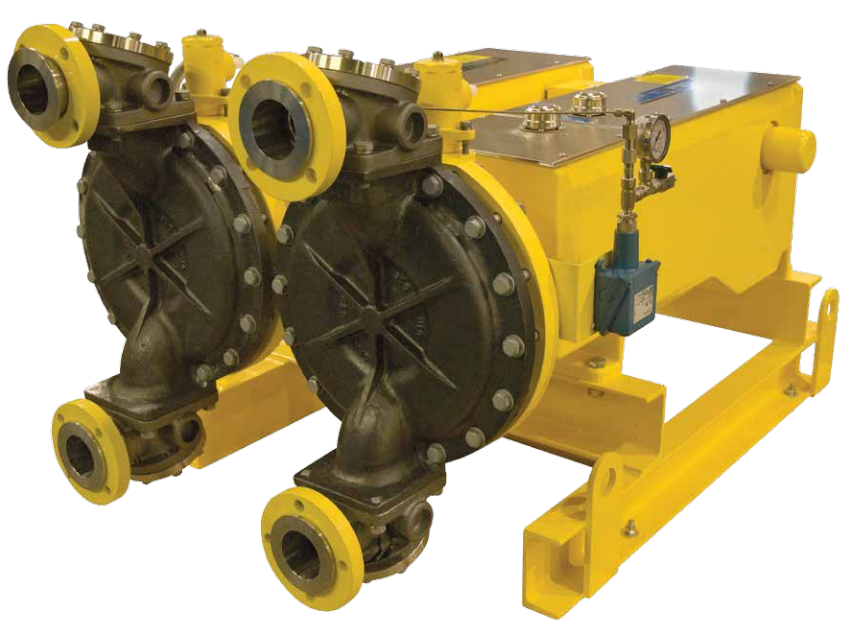
A major Texas refinery was looking for ways to minimize flaring to ensure compliance with these emissions regulations, without eating into their profit margins. The refiner settled on a solution to capture some of the flare gases that are normally burned off and compress them into a liquefied petroleum gas (LPG) product containing primarily propane and smaller concentrations of other volatile hydrocarbons. This LPG would then be slowly injected into the refined product.

While this process promised the refiner significantly reduced flaring emissions, it also presented major challenges. First, the LPG would have to be maintained in a liquefied state, and second, the injection of the LPG would have to be carefully controlled so as not to jeopardize the quality of the refined product.

The centrifugal pump that the refiner initially installed for this application, could not reliably pump at the product's low vapor pressure, which ranged from 40 to 100 psig. The refiner approached pump specialist Milton Roy to help engineer and install a pumping solution to address these challenges.

REVIEWING OPERATING PARAMETERS

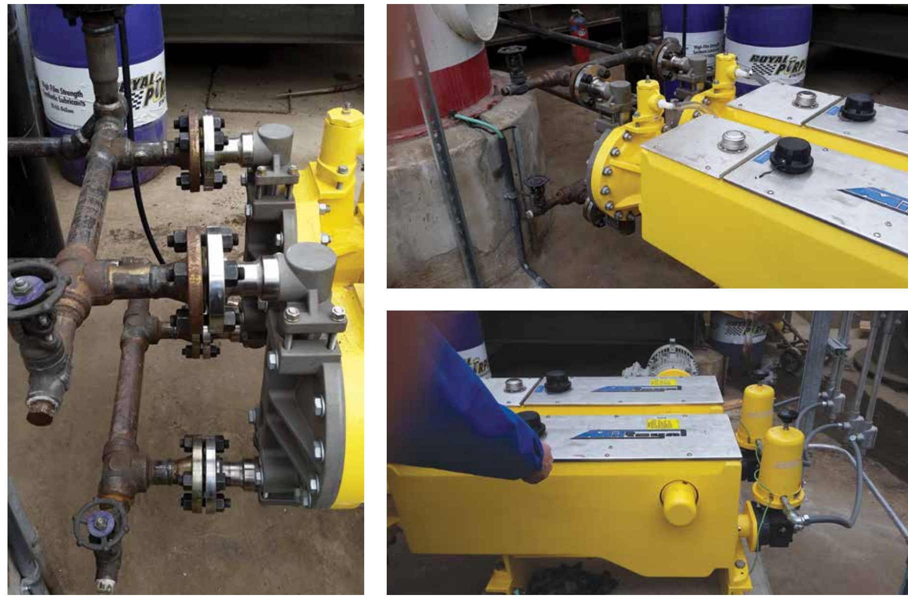
The refiner presented Milton Roy with the operating parameters and project requirements for the



The Duplex Positive Displacement Pump with High-Performance Diaphragm Liquid End desired pumping solution. Because they already had experience using centrifugal pumps, the refiner wanted to use another sealless type—either a magnetic drive or a canned motor pump—for this application by adjusting the pump's design parameters.

The pump would have to increase the pressure of a liquid propane feed with a density of 33 pounds per cubic feet at 32 degrees Fahrenheit by 70 psig. The pump would also require a net positive suction head available (NPSHA) of at least 78 feet for propane and 194 feet for water. The pump would have to produce a head of 308 feet (propane) and 164 feet (water) and have a discharge pressure of 140 psig to pump LPG at a rate of approximately 36 gal/min.

A thorough review of available magnetic drive and canned motor sealless pumps revealed fundamental design limitations that would hinder the performance for the application.



Installation of the Milton Roy Milroyal C Metering Pump

Keeping the LPG in liquid form was already a challenge in central Texas, where average temperatures ranged from 50 degrees Fahrenheit (10 degrees Celsius) in the winter months to well over 80 degrees Fahrenheit (27 degrees Celsius) in the summer. Even with insulated lines, the warm ambient temperatures, coupled with the heat coming off the metal surfaces making up the refinery equipment, implied that the LPG would not remain at 32 degrees Fahrenheit for long after it left the storage vessel. A rise in temperature of even a few degrees brings with it a rapid rise in the product's vapor pressure.

The low operating efficiencies of centrifugal pumps make this problem even worse. Only 10-20 percent of a centrifugal pump's energy goes to moving the fluid, with the remainder being dissipated as thermal energy generated by eddy currents produced in the rear casing of magnetic-drive pumps, and friction losses in the rotating assembly.

The LPG absorbs this thermal energy, which brings about an increase in fluid temperature and vapor pressure that can lead to liquid flashing and premature failure of the pump. In addition, the portion of the product that reverted back to the gaseous phase would have to be sent to the flare stack, which not only lowers the refiner's revenues but also risks putting them out of compliance with flaring regulations.

Milton Roy and the refiner jointly concluded that this efficiency problem was inherent to any model of centrifugal pump and determined that a metering pump would provide a viable alternative.

METERING PUMP PRINCIPLES

The metering pump proposed for the application was a Milroyal C reciprocating positive-displacement, controlled-volume metering pump. The pump had a track record of successful deployment in knockout drums and other services that require pumping extremely low vapor pressure fluids. The pump was offered in a duplex, parallel arrangement.

The pump selected provides a fully compliant API 675 solution for the refiner. Metering pumps require very little suction pressure to operate and offer much higher efficiencies—typically 85 percent to 95 percent—which minimizes the risks of product flashing in the pump, and requires less horsepower to operate.

The team selected this pump because of its modular design and accurate flow control capabilities. The modularity includes multiplexing capabilities, where one to six pumps can be configured to provide a maximum of 25 horsepower of pumping power. The pump can also accept various liquid ends, including several types of packed plungers or a high-performance diaphragm. For this specific application, a duplex pump with a leak-proof Teflon diaphragm liquid end was selected.

The pump consists of a drive unit, a reciprocating plunger mechanism, and the diaphragm liquid end. The drive unit operates on a patented polar crank principle, in which a crank driven by a worm gear rotates on a variable plane to generate a reciprocating motion of the plunger. At the start of a suction stroke, the plunger moves away from the liquid end, drawing hydraulic fluid with it. This subsequently draws the diaphragm back, which lowers the pressure on the LPG in the liquid end. The lower pressure causes the fluid to flow inward and lift a suction ball check valve. The LPG then passes through the suction line and into the diaphragm head, while simultaneously pulling a discharge ball check closed to block flow through the discharge line.

The process reverses at the end of suction stroke. The discharge stroke begins with the plunger moving forward and pushing the hydraulic fluid in front of it. The hydraulic fluid presses against the diaphragm, flexing it forward and raising the pressure on the LPG in the liquid end. The pressure buildup forces the discharge ball check valve open and the suction ball check valve to seat, thus blocking flow through the suction line. The LPG fluid then flows out of the diaphragm and into the discharge line. This suction/discharge action repeats with every stroke of the pump plunger.

PROVING ITS POTENTIAL

After several months of collaboration to design and engineer the specific pumping solution to meet the refinery's operating requirements, the duplex pump was installed. The pump worked flawlessly from the start, increasing the LPG pressure and achieving the 36 gallons per minute pumping rate to safely and accurately dose the fluid into the refined product at the precise dosage requirements.

The highly efficient pumping solution has run leak-free and allowed the refiner to avoid flaring any LPG to the flare stack. The system's 85 percent plus efficiency allowed the refiner to use a 1-horsepower AC motor to run both pumps. Part of the power savings came from running the two pumps 180 degrees out of phase and applying power to one pump at a time. An added benefit not expected at the start of the project was that the application of the metering pump significantly lowered the refiner's electricity spend.

For the facility as a whole, the application has contributed to a 40 percent reduction in overall flare emission costs, while ensuring compliance with regulatory requirements. ◆

Milton Roy manufactures controlled-volume metering pumps for a wide range of industries and applicaitons. For more information, visit **www.miltonroy.com**.