THE VAPOR JET SYSTEM - A METHOD FOR VAPOR RECOVERY

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Abstract

The Vapor Jet System is an alternative to conventional vapor recovery technology for the recovery of hydrocarbon vapors from oil production facilities' storage tanks. The process utilizes a pump to pressurize a stream of produced water to serve as the operating medium for a jet pump. The potential energy (pressure) of the produced water stream is converted to kinetic energy (velocity) in the jet pump. The high velocity water stream entrains the near atmospheric pressured vapors and returns them to the facilities' low pressure system for separation and sale. The water is then returned to the water storage tanks for further de-gassing and reuse in the Vapor Jet System process, disposal or injection.

The Vapor Jet System is simple, cost effective and virtually maintenance free. The Vapor Jet System can be installed for significantly less than compressor based systems and over the life of the installation operate at a fraction of their operating expenses.

Introduction

Historically, the recovery of hydrocarbon vapors from the oil and water storage tanks of oilfield production facilities was generally thought to be an uneconomical venture due to low gas prices and small gas volumes involved. Often, those installations identified as having economically justifiable vapor volumes, were not equipped with vapor recovery systems due to the significant initial investment and high operating expenses associated with those systems. For most operators, vapor recovery on their production facilities was a poor way to spend their capital and expense dollars.

Economics are no longer the sole factor in the decision to recover tank vapors. The Clean Air Act of 1990 and stringent state air quality standards regulates oil production facilities' air emissions by imposing fees for those emission levels in compliance and fines for those found to be out of compliance. The control of air emissions from oil production facilities may mean the difference between continued operations and shutting down.

For many oil production facilities, a major contributor to total air emissions are the hydrocarbon vapors vented to the atmosphere from the oil and produced water storage tanks. In some cases, as little as 5 MSCFPD of tank vapors can require permitting and the implementation of control technology. If such low gas volumes from tanks alone could mean non-compliance, with all air emissions considered, a significant number of production facilities will require tank vapor emission controls.

If vapor recovery is no longer an option, but a necessity, then the production operator needs to determine the most effective and economical process available to him. The patented Vapor Jet System gives him an alternative to the traditional vapor recovery methods.

System Description

The Vapor Jet System utilizes a jet pump (a.k.a. a venturi, eductor or ejector) and lease produced water as the operating medium for that pump. The produced water is pressurized to 200-225 psig by a single stage centrifugal pump driven by an electrical motor and discharged to the inlet of the jet pump (see Fig. 1). The jet pump has an inlet for the operating medium entry, a suction for the gas entry and a discharge for all fluids. The water entering the jet pump travels through a nozzle, which converts it to a high velocity stream, as it enters the suction chamber. Tank vapors, at near atmospheric pressure (2 - 4 oz./sq.in.), are piped from the tanks to the suction chamber of the jet pump. The high velocity water stream, which has lowered the pressure in the suction chamber to a vacuum, entrains the tank vapors. The operating medium, with entrained vapors, now travel to the diffuser section of the jet pump where the kinetic energy of the high velocity stream is converted to potential energy, resulting in a pressure that is greater than the suction chamber pressure , but significantly less than the pump entry pressure. The discharge of the jet pump is piped to the production facility's low pressure separation system (< 40 psig) where the vapors are separated from the produced water operating medium and sold along with other lease gas. The produced water used in the process now returns to the water storage tanks for further de-gassing and re-use in the vapor recovery process, disposal or waterflood injection purposes.

A pressure controller activates the Vapor Jet System, by turning on the centrifugal pump, when the pressure in the vapor space of the tanks has reached a pre-determined point (2 - 4 oz/sq.in). When the necessary volume of gas vapors have been removed from the tanks to lower the pressure to a pre-determined point (1 -3 oz/sq.in.), the pressure controller deactivates the system by turning off the pump. These pre-determined tank pressure settings can and do vary from installation to installation.

Equipment Description

The major components of the Vapor Jet System are:

1. <u>Jet pump</u>
   The jet pump is sized based on maximum anticipated vapor volumes. The size of jet pump will determine the rate of water (gpm) that must be pumped. Although jet pumps will work at different pressures, the Vapor Jet Systems in operation utilize an inlet pressure of 200 - 225 psig, where the discharge pressure must be less than 40 psig to create a vacuum in the suction chamber and allow the system to work.

   The Vapor Jet Systems that have been installed utilize 1 ½", 2" and 2 ½" jet pumps. (See Table 1)

2. Electrical motor driven centrifugal pump with motor starter
   The centrifugal pump is sized to move the required rate and at the pressures to operate the particular size of jet pump. The sizes of the motor and motor starter are then determined that will drive the pump.

3. Water piping
   The produced water to operate the jet pump must be piped from the water storage tanks to the centrifugal pump, the centrifugal pump to the jet pump and from the jet pump to the facility's low pressure separation system. A basket strainer upstream of the jet pump has proven adequate to protect the jet pump's internals. A check valve must be installed downstream of the jet pump to prevent backflow from the facility's low pressure separation system.

The following components are required to make the Vapor Jet System effective and a complete vapor recovery system and are also required for the operation of other methods of vapor recovery.

4. Pressure controller
   The Vapor Jet System utilizes an electronic tank pressure controller device capable of the measurement of low pressures. The device used has a range of 0 – 235 oz./sq.in. with four point card and LCD display.

5. Vapor collection piping
   The piping to transport the gas from the tanks to the suction of the jet pump should be properly sized to allow unrestricted flow of the gas at the very low pressures involved (< 4 oz/sq.in.).

6. Make-up gas system
   A make-up gas system is essential to the operation of the Vapor Jet System, as well as to any other method of vapor recovery. A positive pressure must be maintained, in the tanks, at all times to prevent oxygen entry into the production systems.

7. Leak free tanks
   Tanks must be free of leaks to prevent the loss of vapors to the atmosphere and to ensure that a positive pressure is maintained on the tanks.

8. Pressure – vacuum devices
   Pressure – vacuum devices should be used to prevent damage to the tanks.

System Considerations

The Vapor Jet System requires:

1. An adequate supply of water to serve as the operating medium for the jet pump. In areas, such as the Permian Basin of southeastern New Mexico and West Texas, the availability of significant volumes of produced water is usually no problem, for most operators. As one of the components of the producing well's production stream, the water had gas in solution under reservoir conditions. The saturated water will continue of emit gas at each lower separation pressure, ultimately subjected to lowest separation pressure and maximum retention time in the storage tanks. The gas coming out of solution in the water will combine with oil solution gas to represent total tank vapor volumes.

2. Low pressure separation equipment capable of handling the additional volume of water and gas circulated intermittently by the Vapor Jet System. Some Vapor Jet installations have their own separation vessels and are not commingled with the production stream.

3. A low pressure (< 40 psig) in the facility's low pressure separation system. The jet pump is sized with an inlet pressure of 200 – 225 psig and a downstream pressure of 20 psig. As the downstream pressure increases, the jet pump loses its gas moving capabilities. Pressure drop in the piping downstream of the jet pump is critical and must be kept to a minimum.

Advantages

- Reliable. Virtually no downtime.
- Simple. Operator friendly. Easy to understand.
- All components are tried and proven oilfield equipment, with shelf availability, that can be changed out quickly, if required.
- One size of centrifugal pump for the three sizes of jet pumps currently in use.
- Clean. No lubrication system to maintain.
- No compressor overhauls.
- No cooling system to maintain.
- No separate gas metering.

Low Capital Cost

The total cost to install a Vapor Jet vapor recovery system on a two to four tank facility can be significantly less than a compressor-based system. This cost includes labor, licensing fee and all equipment previously described as unique to the Vapor Jet System, as well as all controls and equipment required on any compressor-based vapor recovery installation. The three sizes of jet pumps currently in-use use the same size single stage centrifugal pump, changing impeller, motor and motor starter size between the three applications.

This cost will vary depending on location, operator, labor costs and whether the installation is on newly constructed or retrofitted to existing facilities.

Low Operating Costs

Virtually the only expense of the Vapor Jet System is the cost of electricity to drive the centrifugal pump. Operating experience has shown that minimal maintenance is required, which accounts for minimal downtime. The centrifugal pump and motor are the only equipment required that has moving parts and is very durable, even when pumping produced water. Although lacking in efficiency, the single stage centrifugal pump's ability to pump produced water reliably with very little maintenance more than compensates when considering the overall costs of vapor recovery.

Table 1 shows the three sizes of Vapor Jet System in operation, along with the operating medium required pressure and rate. The gas volume recovered shown is the volume of gas that can be recovered per day, if the system operates continuously. The table gives the cost of electricity per Mcf of recovered gas along with data used to calculate these costs.

The 1 ½ " jet pump sizing is used when vapor volumes are less than 15 Mcfpd so that the system will operate less than 100 % of the time. The centrifugal pump is at a low efficiency, resulting in an electrical cost of 74 cents per Mcf recovered, when using a power cost of 4 ½ cents per KW-HR. This size system is used when lower volumes of gas vapors must be recovered. Because this size Vapor Jet System can recover any small volume of gas and do it at a low cost, it is a good method to consider when emission control outweighs economic payout.

The 2 " jet pump is used when vapor volumes are 15 – 35 Mcfpd. The efficiency of the centrifugal pump has improved with the resulting cost of 45 cents per Mcf of gas recovered. The 2 ½ " jet pump allows the centrifugal pump to operate at its most efficient point with a resulting cost of 36 cents per Mcf of gas.

Compressor based vapor recovery systems use less electricity to operate than the Vapor Jet Systems. In an application where vapor volumes to be recovered are 25 Mcfpd, the compressor-based system could operate with a 7.5 HP motor and have an electrical cost of 27 cents per Mcf of gas recovered. The Vapor Jet System would employ the 2" jet pump size, which operates at 45 cents per Mcf, or 18 cents per Mcf, more than the compressor-based VRU. This would equate to a $ 4.50 per day savings in electricity for this 25 Mcfpd application.

If you compare total operating costs for a Vapor Jet System and a compressor-based vapor recovery system in a new properly designed, properly installed and properly operated installation, the Vapor Jet System will have higher expenses due to the electrical costs as shown above. The costs of lubricating oil, routine maintenance and compressor overhauls have not been considered, but will increase for the compressor-based system as it ages. The $ 4.50 per day savings in electricity, as shown above, is only $ 1642.50 per year. Once this threshold of expenses has been reached for the compressor-based system, the Vapor Jet will have lower expenses and operate at a fraction of the cost.

Conclusions

1. The Clean Air Act of 1990 and stricter states' air quality standards will require many oil production operators to implement air emission controls on their production facilities. As the hydrocarbon vapors from oil and water tanks can represent a significant portion of total facilities' emissions, the recovery of these vapors may be required. Production operators must have a way to recover tank vapors at low volumes historically considered uneconomical or even feasible, in order to comply with the law.

2. The Vapor Jet System is a method of vapor recovery that will allow production operators to recover tank vapors to any low volume level required. It is a simple and reliable system that can be installed economically, while operating costs can be significantly less than other vapor recovery methods.

References

1. The Clean Air Act of 1990

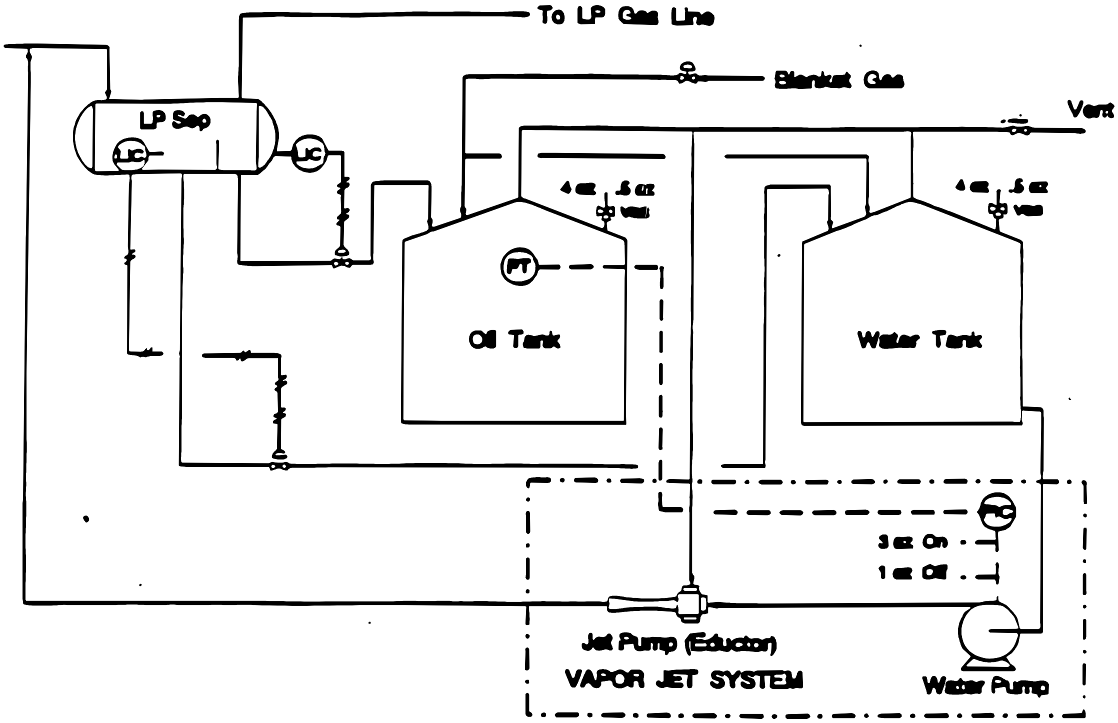

Figure 1 Schematic – Vapor Jet Vapor Recovery System

Table 1 Jet Pump Sizing

Jet Pump Size (in.)	1 1/2	2	2 1/2
Operating Medium Pressure (psig)	200	200	200
Operating Medium Rate (gpm)	45	82	143
Gas Volume Recovered (Mcfpd)	25	45	77
Centrifugal Pump Eff. (%)	26	42	53
Motor Eff. (%)	0.9	0.9	0.9
KW-HR/day	401	453	625
Power Cost ($/KW-HR)	0.045	0.045	0.045
Electrical Cost ($/Mcf)	0.74	0.45	0.36

Table 1 Jet Pump Sizing – Vapor Jet System