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Technologies, Best Practices Helping Producers Manage Compressor Emissions

By Aleksey Dubrovensky
and Craig Martin

JEFFERSONVILLE, IN.–Rapidly changing energy markets and stringent new emissions regulations from the U.S. Environmental Protection Agency are combining to make measuring and controlling fugitive emissions a top priority for the American energy industry. Numerous innovations are being implemented by U.S. natural gas producers in order to monitor and control these fugitive emissions.

However, government regulations are not the only force driving the increased focus on measuring and controlling fugitive emissions. A combination of rising global energy demand, tightening oil supplies, and horizontal drilling and hydraulic fracturing technologies has produced a worldwide boom in natural gas production. The trend is particularly pronounced in the United States, with the rapid development of vast new natural gas reserves in shale rock formations as well as associated gas and natural gas liquids in tight oil plays. As these huge new reserves are developed, the value of each additional cubic foot of natural gas recovered increases.

This energy boom has led to a sudden increase in the demand for field operators, leading to a shortage of capable workers in many parts of the country. This labor shortage has pushed wages upward and has left many operators seeking new ways to maximize the return on their equipment and employees.

In light of this, improving the reliability of their equipment also has become a focus for many operators. Machine throughput and uptime have become critical in today's operating environment. Operating efficiency has become a competitive necessity, and many oil and gas companies are relying on an increase in the life span of their production equipment.

The EPA has decreed that the "best available methods must be used to measure all greenhouse gas emissions," according to the document *Petroleum & Natural Gas Reporting Rule: Subpart W (40 CFR Parts 98)*. A greenhouse gas is defined as any gas that absorbs infrared radiation, and includes water vapor, methane, nitrogen oxides, chlorofluorocarbons, sulfur fluorides, carbon dioxide, chlorodifluoromethane, hydrofluorocarbons, and perfluorocarbons.

The EPA has mandated that any petrochemical producer or user must monitor its emissions or face significant monetary penalties. Currently, regulators are content with merely monitoring emissions, but in the future they could implement taxes or cap-and-trade restrictions on emissions as well.

Major Issue

All of these developments have combined to make measuring and controlling fugitive emissions from natural gas compression equipment a major issue. The majority of natural gas compression equipment is reciprocating compressors, as they are the most efficient method to transport massive quantities of gas out of the rock formation and through the gathering system to the processing plant or pipeline.

There are numerous potential leak points inside a reciprocating compressor, as illustrated in Figure 1. While the packing case vent is the most common and well known area where fugitive emissions are found, it is certainly not the only place. Fugitive emissions can escape from the compression cylinder through the packing case nose gasket, between packing case cups, through valve cover gaskets, out valve unloader packing, and through the distance piece vent/drain.

In fact, according to an EPA Natural Gas STAR publication titled *Reducing Methane Emissions from Compressor Rod Packing Systems* published in July 2003, "the failure to account for emissions escaping into the distance piece may result in underestimating packing-related emissions by up to 40 percent."

Even when an operator has implemented a flowmeter in the packing case vent line to measure the fugitive emissions coming out of the packing case, he may still be missing a substantial level of the emissions that are leaving the compressor cylinder. That can lead to costly fines and restrictions when state and federal emissions testers examine the emission levels at the operator's facilities.

Emissions Management

There are a number of approaches being developed and implemented in the field of emissions management. One approach is a vapor recovery system, which seeks to channel emissions back to a controlled source. This usually involves reconfiguring the compressor installation and the piping.

Another approach is to modify packing cases to reduce the leakage. A common iteration of this approach is to install two vent seal rings inside the same packing case. One vent seal ring is installed downstream of the vent cup, where it can prevent emissions from escaping down the piston rod. The second vent seal ring is installed upstream of the vent cup to prevent emissions from even entering the vent line. Field testing has confirmed that this approach yields significantly reduced leakage levels.

However, this solution comes with an important drawback. Because the vent seal ring is side-loaded, it is constantly applying force to the compressor rod, which reciprocates through the packing case and moves at several hundred linear feet a minute inside of a typical compressor. This creates a large amount of frictional heat buildup on the compressor rod, which can have a significant effect on the performance and reliability of the compressor.

Testing carried out by a compressor sealing component manufacturer has confirmed that adding a vent seal ring upstream of the vent line can increase piston rod temperatures by as much as 100 degrees Fahrenheit. This additional heat can cause premature wear of the pressure packing and also can increase leakage rates.

A new innovation has been introduced that appears to combine the emissions-reducing properties of the vent seal rings approach while reducing the frictional heat loading on the piston rod. This low-friction seal technology consists of installing a cup in the packing case directly upstream of the vent cup. It is intended to prevent emissions from entering the

FIGURE 1

Potential Leak Points in Reciprocating Compressor

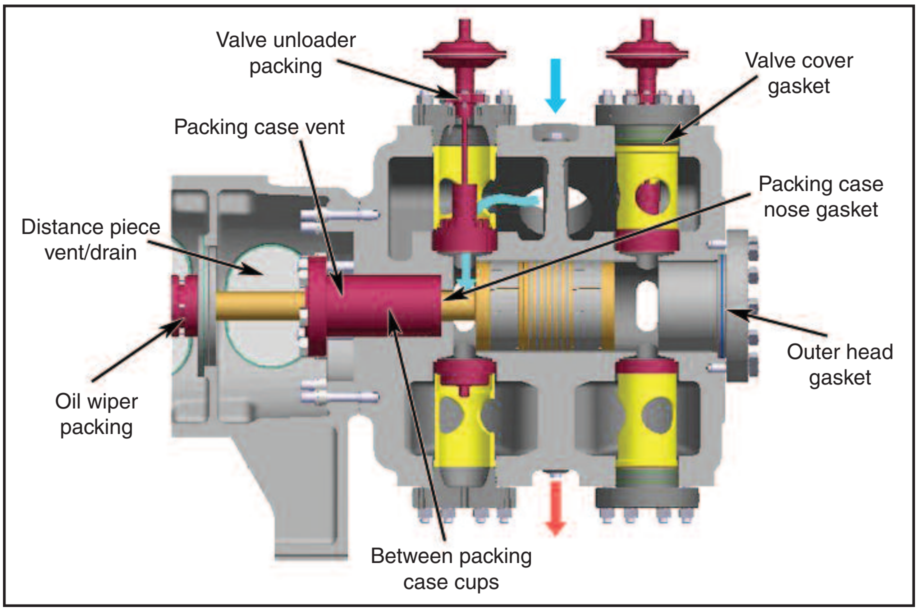


FIGURE 2

Low-Leak Packing Rings

vent line, just like a traditional vent seal cup, but it has the added advantage of reducing the fictional heat loading on the piston rod.

Significant fugitive emissions can result not only from operational compressors, but also from static cylinders. Field testing has determined that while operating cylinders with traditional pressure packing materials and designs can yield vent line emissions of 0.05-0.1 cubic feet a minute, static cylinders on identical machines at the same installation produced 9.0 cubic feet/minute of leakage through the vent line, representing a 180-fold difference. At a price of $8.00 a dekatherm, this can result in nearly $40,000 of lost annual production.

Upgraded Packing

Another approach to reducing vent line emissions is to install upgraded pressure packing designs and materials into the packing case. A special class of so-called low-leak packing has been in use for a number of years, and it has yielded impressive results compared with standard packing designs and materials. Figure 2 shows an example of low-leak packing rings.

These new pressure packing rings are made with multiple rings (up to four rings in some cases) in a single groove, and they usually have a mix of materials among the individual rings in a single groove. This allows each ring in the groove to provide dynamic sealing in the packing cup as the piston moves through its compression stroke and the pressure in the cylinder builds (Figure 3).

This packing is made so that only a single ring in the groove is sealing at a particular pressure, rather than having all the rings in a groove sealing simultaneously. This dramatically reduces the cross-area of the ring that is actively sealing against the piston rod at any one moment, significantly reducing frictional heat loading on the piston rod. Field and laboratory testing has confirmed these results.

Not all of the innovations being employed by natural gas operators are necessarily novel or high-tech. Some operators have taken a more back-to-basics approach in maintaining their machines in order to achieve their goals. For example, instituting best practices in packing case maintenance is a good way to maximize the life span of the pressure packing, as well as to reduce the fugitive emissions coming from that case.

These best practices include upgrading the nose gasket to a spiral-wound gasket design; replacing double-acting vent seal rings with more modern side-loaded vent seal rings; lapping the mating faces of the individual packing cups; verifying the parallelism of cup faces, cup depths, pressure packing ring clearances, the piston rod surface finish, and the packing case alignment; and ensuring that proper flange bolt tightening procedures are being used. All of these basic maintenance practices can reduce fugitive emissions by significant amounts.

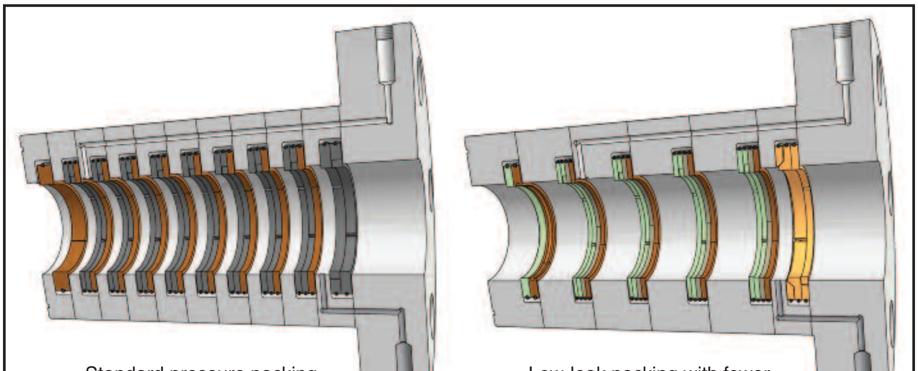
Some operators are going even further and are evaluating other potential emissions sources, such as valve-related leakage. Valve unloaders can have inadequate sealing around their actuator rods. These unloaders come standard with a set of rope packing, which can allow fugitive emissions to escape from the unloader. In order to reduce these emissions, a special seal cartridge can be installed in place of the standard rope packing.

Another potential leakage source is jack-bolt-style retainers in valve cages. Poor sealing around the jack bolt results in fugitive emissions that can prove hazardous to people and the environment. A high-strength retainer design can reduce some of this leakage. This design includes a robust O-ring around the cage jack bolt to provide superior sealing, and replacing the single jam nut with a multiple jam nut design.

There are numerous strategies being employed by natural gas producers to reduce emissions from their compression equipment. These changes are being brought on by a rapidly evolving regulatory environment and by changing economics in the energy industry. ❒

FIGURE 3

Standard versus Low-Leak Pressure Packing



Standard pressure packing with multiple seal rings

Low-leak packing with fewer, more effective seal rings

ALEKSEY DUBROVENSKY

Aleksey Dubrovensky is a project engineer with Cook Compression in Jeffersonville, In. In this role, he collaborates with customers and sales representatives to identify market opportunities by applying specialized engineering solutions. Dubrovensky has five years of industrial experience. He holds a bachelor's in mechanical engineering, economics and engineering management from Vanderbilt University School of Engineering. He is pursuing an M.B.A. from Indiana University.

CRAIG MARTIN

Craig Martin is manager of applications engineering with Cook Compression, and is responsible for all day-to-day engineering activities and technical interaction with customers. Martin has been with Cook Compression since 2004, and has worked primarily with piston ring and rod packing products.