REDUCING HYDROCARBON EMISSIONS IN GAS LIFT OPERATIONS

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ABSTRACT

Gas lift is long known to be an effective and versatile form of artificial lift and is widely used in oil and gas production. Compressors are a vital part of the gas lift process and are present in large numbers in the oil and gas industry. The design of these compressors has for many years allowed for the release of hydrocarbons into the environment. Concerns over the environmental impact of these hydrocarbon emissions has increased scrutiny by the public eye and environmental regulators. In turn oil and gas operators are seeking ways to reduce hydrocarbon emissions to the environment from the compressors required for the gas lift process. A new and patented system has been developed to eliminate hydrocarbon emissions from compressors. This system is disclosed, and an operator's perspective is shared in how it is helping them to the environmental impact of their gas lift operations.

INTRODUCTION

Gas lift is a versatile and robust artificial lift method that is now a preferred artificial lift method with many operators in their Permian Basin unconventional resources (Richter, et al. 2016). Gas lift is dependent upon pressures not naturally found in most production environments, however. Thus, a gas compressor must be employed to increase the pressure of gas to be used in the gas lift process (Nelle, 2023).

Inherent to the design of virtually all compressors in use in gas lift and the larger oil and gas industry today are hydrocarbon leaks. Cost effective compressor package designs depended upon allowance of them. Further, the leaks were deemed small and insignificant, thus these leaks have been accepted. However, growing concerns over global warming has increased scrutiny over hydrocarbon emissions to the atmosphere. Compressors designers and compressor operators alike are confronted with understanding and addressing hydrocarbon leaks from compressors. But that is not an easy task. First, the oil and gas industry tends to be loyal to longstanding practices and not readily accepting of new ideas and designs. Additionally, over 50,000 compressors exist within the oil and gas industry (EPA, 2008). Modifying such a large population of compressors is costly and time-consuming. Fortunately, innovation is bringing new solutions to the industry and environmental regulations are challenging longstanding mindsets, progressing the task of reducing hydrocarbon emissions from gas compressors.

HYDROCARBON LEAK POINTS ON COMPRESSORS

Fundamental to understanding how to reduce hydrocarbon emissions from compressors is an understanding of the leak points on compressors. Most field gas compressors used in gas lift emit hydrocarbons, intermittently or continuously, from four different points:

1. Blowdown of the compressor process system
2. Venting of pneumatically powered devices
3. Compressor piston rod packing leaks
4. Blowby from engine power cylinders

Each of these leak points is explained in more detail below. The discussion will be general and cannot go into detail regarding leak rates as each different compressor design will vary in the volume leak rates.

Blowdown of the compressor process system is when gas that is contained within the compressor process system (piping, pressure vessels, compressor cylinders, and gas cooler) is vented to the atmosphere. A simple process, the compressor operator typically opens a ball valve attached to the discharge pipe of the compressor and pressurized gas flows out of the process piping into a pipe that is open to atmosphere (EPA, 2006). For a short period of time (typically about 30 seconds to one minute) gas flows at a high rate. At the end of the process, the compressor process system is at atmospheric pressure and the volume of the gas that was previously contained in the process system is now permanently lost to the atmosphere.

Venting of pneumatic powered devices is when gas that is used to power devices on the compressor is vented to atmosphere. Examples of these devices include control valve actuators, cooler louver actuators and pneumatic motors (engine starters, pneumatic pumps). Generally pressurized gas is supplied to the device, and the potential energy contained within the pressurized gas is converted into kinetic energy that powers the device. Given that power generation is a function of the differential pressure of the gas, upstream vs downstream of the device, the downstream pressure is as low as possible and oftentimes atmospheric. Figure 1 below shows a cutaway view of a pneumatically actuated valve as would be used to drain fluids from a pressure vessel (scrubber dump control valve). The yellow portion of the figure valve is pressurized with gas each time the valve needs to stroke/actuate and then subsequently vents to atmosphere when the valve closes. Generally, pneumatically actuated valves and louver actuators vent gas to the atmosphere intermittently and at low volumes. Engine starters also vent intermittently, although the flow rates are considerably higher during the vent duration.

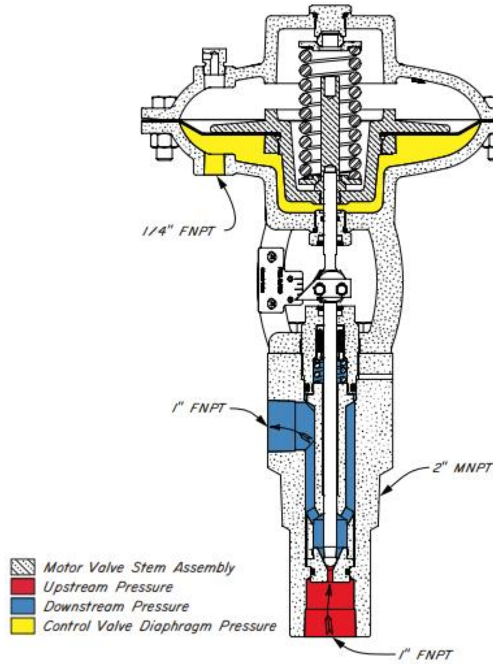

Figure 1 – Cutaway diagram of a pneumatically actuated control valve

Compressor piston rod packing (reference Figure 2) leaks when gas from inside of compressor cylinders seep past the seal (rod packing) between the compressor cylinder and the compressor piston rod. The compressor piston motion is induced by the piston rod, which is connected to the (external) crosshead. The rod packing serves to seal the gas inside of the cylinder. However, the seal is a "dynamic seal and will have some leakage" (Application Manual, 2023). Leaks past rod packings are continuous during operation of the compressor and must be vented to near atmosphere pressure to prevent damage to the packing.

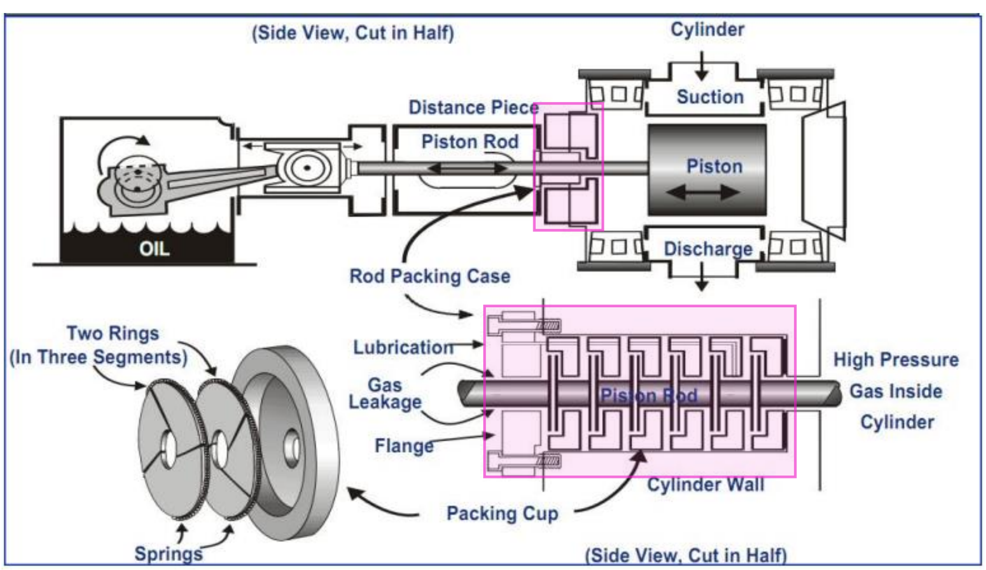

Figure 2 – Compressor cutaway, highlighting rod packing

Blowby from engine power cylinders is where gases escape around piston rings and into the crankcase (Olsen, 2023). Blowby gases are a combination of air, hydrocarbons, and other products of combustion. These gases must be removed from the crankcase to prevent oil contamination overpressure in the crankcase. Venting blowby gases to atmosphere is the longstanding method of dealing with blowby gases.

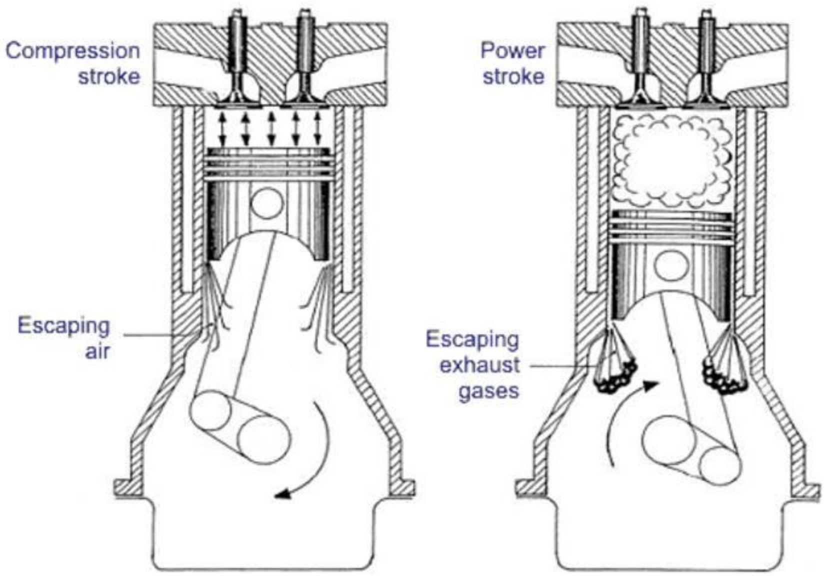

Figure 3 – Engine crankcase blowby

Note that each of the four leak sources end up at atmospheric pressure. That is not done for the sake of convenience, but that each of the processes need to end up at the lowest possible pressure. To end up at atmospheric pressure, either the process must vent to atmosphere, or a pump be installed to remove the gases and send them to some other process. Adding a pump to each system has not been deemed necessary in the past due to less stringent environmental regulations and the desire to minimize equipment cost. New environmental regulations call for answers other than venting the gases to atmosphere. Yet, the desire to control equipment cost calls for solutions other than installing pumps on each separate process.

<u>PAST SOLUTIONS</u>

The problem of venting hydrocarbons into the atmosphere is not new and various solutions have been attempted with varying degrees of success and acceptance. Previously, no single solution has been developed that addresses the venting gas from each of the four leak sources discussed. Some have taken multiple systems and packaged them together to address multiple leak sources. While this approach can reduce hydrocarbon emissions, the approach can be expensive and cost prohibitive to the size of compressor that is often deployed in gas lift applications (Robbins, 2022).

Reviewing the approaches and solutions that are used individually can be instructive and give engineers and operators with options if a complete solution is not required.

Perhaps the most frequently employed solution to reducing hydrocarbon leaks to atmosphere is the use of instrument air in lieu of instrument gas. Pressurized gas is present at every gas lift installation and thus is a natural choice for powering pneumatic devices. It is simple to replace instrument gas with air and largely only requires the addition of an air compressor. Air dryers are also commonly installed to decrease the potential for condensation and freezing of moist air. Industrial air compressors are reliable, but costly and can add to the lease operating expense (LOE) of the gas lift operation. Much attention and money has been expended to addressing this type of leak. Yet, to the surprise of many, this is the lowest leak rate of the four discussed. Practically, this results in a high cost per volume of gas abated. An additional challenge to converting to instrument air is the need for electrical power at the site. While electricity is increasingly available in the oilfield, upstream oilfield locations where gas lift operations are occurring do not all have power present.

Reducing hydrocarbon leaks due to compressor blowdowns have been addressed in a couple of ways. First, operators can route blowdown gas to low pressure piping systems that retain the gas instead of venting the gas to atmosphere. The inlet side of the compressor system is commonly fed by a piping system that has large volumes and can readily accept the volume of gas contained within the compressor process system without becoming overpressured. While this is a viable and inexpensive method of reducing blowdown gas to atmosphere, it does not entirely eliminate hydrocarbon emissions as the process system can not be brought down to atmospheric pressure in this approach. Rather, the delta in pressure between the inlet gas system and the atmosphere must be relieved to atmosphere. Another way to reduce hydrocarbon emissions from blowdowns is to route the blowdown to a flare system. While flares can destruct the hydrocarbons that would otherwise be emitted to the atmosphere, they do create other emissions that are pollutants to the atmosphere and are regulated. A further downside to flares is the expense of installing one or connecting to it if one is already in place.

Compressor rod packing leaks are one of the major subjects of the EPA’s regulation in NSPS OOOOb. Minimization of leaks from rod packing is best accomplished through regular replacement of rod packing rings, ensuring packing cases are good condition. Old ring designs can sometimes be upgraded to newer technology that by design leak less. Still, rod packing leaks are inevitable (Application Manual, 2023). Thus far, elimination of the leak has only come from installation of a small pump to route the leak to a flare, as is performed in US Patent 11248746. As discussed above in routing blowdown gas to flare, doing so eliminates hydrocarbon leaks, but generates other regulated pollutants.

Blowby from engine crankcases has been addressed very little in the industry and engine crankcase ventilation technology remains quite antiquated, much like that of automobile engines of the 1950s. Few engine manufacturers have developed systems to address blowby and thus this remains the least addressed leak source discussed in this paper. Sadly, of all the leak sources, this remains one of the greatest problems in terms of volume of gas emitted to the atmosphere. While aftermarket crankcase ventilation systems exist that reduce blowby to the atmosphere, use of these systems is practically non-existent within the engines utilized in gas lift applications.

A BETTER SOLUTION

The solutions discussed thus far have indeed been improvements from days of little or no control of leakage. However, these solutions also leave room for advancements, namely in reductions in atmospheric hydrocarbon emissions but also in cost effectiveness. Fortunately, two new and innovative patent pending (Nelle, 2024) solutions have been developed by Estis that offer oil and gas operators a way to cost effectively eliminate hydrocarbon emissions to the environment.

Compressor Emissions eVacuator (ceVac) addresses fugitive methane emissions (pneumatic actuators, rod packing and engine crankcase blowby) from the compressor packages, eliminating their escape into the atmosphere. The emissions are gathered and utilized for engine fuel gas. Not only are hydrocarbon emissions eliminated from entering the environment, but they are also turned into useful mechanical energy. Fuel gas usage is reduced, while engine exhaust emissions remain in compliance with EPA regulations and permitted levels.

Recently enacted EPA NSPS OOOOb regulations now require oil and gas operators to either replace compressor rod packing once per year, or to measure compressor rod packing leak rates, both an expensive and burdensome proposition. ceVac eliminates the need for such measures however, as it falls under what OOOOb classifies as a “closed vent system” (Clifford et al, 2024). ceVac routes methane to a process and eliminates the possibility of methane escape to atmosphere. A pressure monitoring system is present to confirm proper operation of the system.

A desirable features of the system is that it is entirely self-contained, eliminating requirements for off-skid power sources. Another desirable feature of ceVac is that but one moving component exists within the system. This keeps the system simple and minimizes potential for failure. Figure 4 depicts a schematic of the system and how emissions are gathered and routed to the engine fuel system.

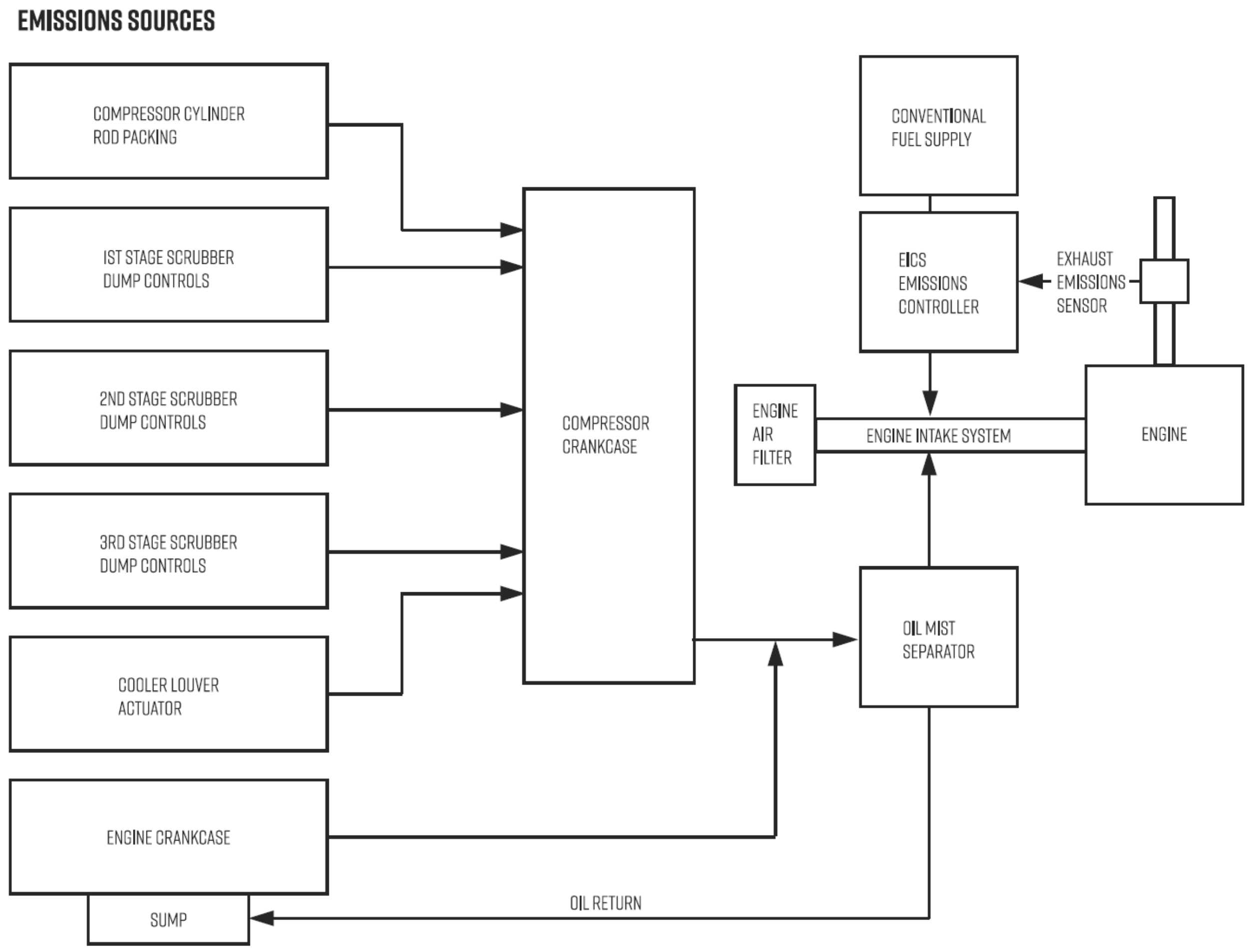

Figure 4 – Schematic of patent pending ceVac system

Methane Retention System (MRS) addresses methane emissions from blowdown of compressor process systems. As the name suggests, methane from the blowdown is retained, in pneumatic accumulators (reference Figure 5 below). Upon compressor shutdown, process gas automatically flows into the accumulators and is retained. Upon restart of the compressor, gas is either reintroduced into the compressor process system, or if paired with ceVac, is burned as fuel gas. Compressor shutdown/restarts where service of the process system is not required (ie: compressor valve maintenance), no venting of methane to atmosphere occurs. When service of the process system is required, methane vented to the atmosphere is reduced on an average of 75% (vs without MRS).

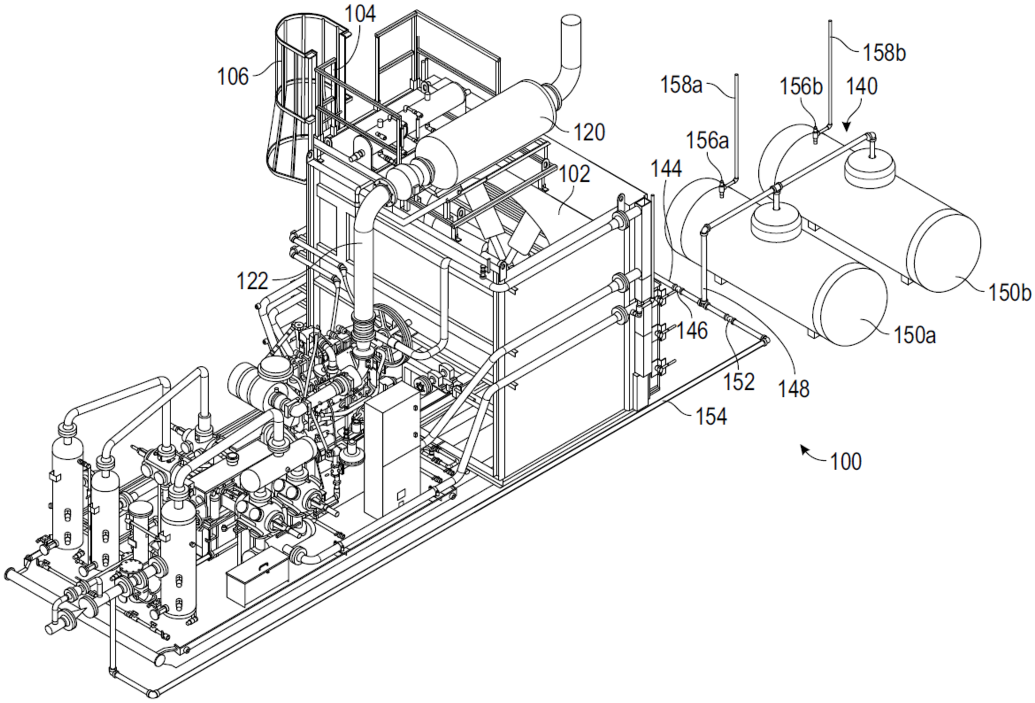

Figure 5 – Concept drawing of patent pending MRS

PRODUCT TESTING

ceVac was first deployed in 2021 on a Cummins KTA19 engine powered compressor package and has run continuously, accumulating nearly 25,000 hours of runtime. Tests have been conducted to confirm the lack of methane emissions being released to the atmosphere. This has been conducted primarily via Optical Gas Imaging (OGI) with a FLIR Gx320 IR camera. Customer feedback was received during this testing that has confirmed the testing.

> "Our thermography team performed a leak survey a few days ago on compressor which currently is operating with a new ceVac system. We could not find any emissions points on the unit during operations. This is great validation on the work your team is doing to commercialize closed vent technology for upstream field compression packages."

Tests have also been conducted to confirm that routing external methane to the engine fuel system does not alter the post catalyst engine exhaust emissions. During that testing, ceVac was operated normally and artificially disabled to allow testing of post catalyst engine exhaust emissions. Figure 6 depicts the results of that testing. Note that the various emissions constituents change very little between ceVac normal operation and disablement.

Parameter	Normal Operation	1-Dump Activated	2-Dumps Activated	3-Dumps Activated	Compressor Disconnected	Engine Disconnected	ceVac Disabled	Engine Crankcase Blow-by[1]
Engine Fuel Flow (SCFH)	2,820	2,820	2,820	2,820	2,838	2,838	2,838	2,838
Stack Flow (RM19) (SCFH)	30,008	30,008	30,008	30,008	30,200	30,200	30,200	33,259
Brake Horsepower (bhp)	369.7	369.7	369.7	369.7	369.7	369.7	369.7	369.7
Engine Load (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
NOx (ppmvd@15%O_2)	12.26	11.70	12.09	12.60	14.44	12.94	13.11	75.97
NOx (g/hp*hr)	1.91E-01	1.82E-01	1.88E-01	1.96E-01	2.26E-01	2.03E-01	2.05E-01	1.19E+00
CO (ppmvd@15%O_2)	71.29	74.21	78.26	76.13	75.97	79.02	76.46	772.27
CO (g/hp*hr)	6.76E-01	7.04E-01	7.42E-01	7.22E-01	7.25E-01	7.54E-01	7.30E-01	7.37E+00
Total HC (as C_3H_8) (ppmvd@15%O_2)	95.54	84.89	86.64	94.03	106.95	89.09	25.54	--
Total HC (as C_3H_8) (g/hp*hr)	1.42E+00	1.26E+00	1.29E+00	1.40E+00	1.60E+00	1.34E+00	3.83E-01	--
Formaldehyde (ppmvd@15%O_2)	0.11	0.14	0.17	0.16	0.13	0.10	0.09	8.57
Formaldehyde (g/hp*hr)	1.10E-03	1.47E-03	1.72E-03	1.59E-03	1.32E-03	1.02E-03	9.04E-04	8.77E-02
Methane (ppmvd@15%O_2)	10.87	10.93	10.89	11.68	12.78	11.41	9.34	12,492.68
Methane (g/hp*hr)	5.91E-02	5.94E-02	5.91E-02	6.35E-02	6.98E-02	6.24E-02	5.10E-02	6.83E+01
Acetylene (ppmvd@15%O_2)	0.19	0.20	0.24	0.20	0.19	0.17	0.12	42.49
Acetylene (g/hp*hr)	1.69E-03	1.76E-03	2.08E-03	1.81E-03	1.68E-03	1.50E-03	1.05E-03	3.77E-01
Ethylene (ppmvd@15%O_2)	4.38	4.23	4.29	4.53	4.61	4.08	3.51	64.11
Ethylene (g/hp*hr)	4.16E-02	4.02E-02	4.07E-02	4.30E-02	4.41E-02	3.90E-02	3.36E-02	6.13E-01
Ethane (ppmvd@15%O_2)	0.46	0.48	0.48	0.48	0.53	0.50	0.14	2,338.23
Ethane (g/hp*hr)	4.69E-03	4.88E-03	4.89E-03	4.86E-03	5.47E-03	5.10E-03	1.42E-03	2.40E+01
Propylene (ppmvd@15%O_2)	25.43	21.95	22.44	24.05	28.56	23.20	30.81	23.28
Propylene (g/hp*hr)	3.62E-01	3.13E-01	3.20E-01	3.43E-01	4.10E-01	3.33E-01	4.42E-01	3.34E-01
Propane (ppmvd@15%O_2)	0.37	0.26	0.01	0.33	0.35	0.29	0.36	4,558.73
Propane (g/hp*hr)	5.47E-03	3.88E-03	1.23E-04	4.86E-03	5.32E-03	4.39E-03	5.40E-03	6.85E+01
Butane (ppmvd@15%O_2)	0.24	0.22	0.15	0.17	0.20	0.24	0.40	651.08
Butane (g/hp*hr)	4.79E-03	4.41E-03	2.96E-03	3.42E-03	3.92E-03	4.84E-03	7.87E-03	1.29E+01

Figure 6 – ceVac Emissions Test Results

MRS was first deployed on a Cummins GTA38 compressor package in 2023 and has run continuously, accumulating nearly 10,000 hours of operation. ceVac was also installed on this same compressor package and working in conjunction with MRS. OGI camera inspections were conducted, yielding no leaks. Further, the same post catalyst engine exhaust emissions tests were conducted, again yielding no appreciable change in engine exhaust levels.

<u>CONCLUSION</u>

Oil and gas operators face pressure to reduce methane emissions to atmosphere. The use of gas lift as an artificial lift method requires the use of compressors, which inherently possess methane leaks. Improvements have been underway for the past several decades to reduce the leak rates. Recent developments have delivered to operators two new patent pending systems that nearly eliminate methane emissions to the atmosphere from compressors used in gas lift applications. Operators are now able to deploy compressors for gas lift operations that emit minimal methane to the atmosphere.

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