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REDUCING EMISSIONS FROM COMPRESSOR SEAL LEAKAGE

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ABSTRACT

The three main types of natural gas compressor used at a pumping station are as follows:

- Centrifugal compressor driven by a high voltage electric motor.
- Centrifugal compressor powered by a gas turbine, which is fired by natural gas from the pipeline itself.
- Reciprocating compressor powered by a reciprocating engine. This engine is also fuelled by natural gas from the pipeline.

Each type of gas compressor uses seals, either wet or dry, as part of its construction. Regardless of what type of compressor, or what type of seal is used, gas leakage occurs. To prevent natural gas venting to the atmosphere, pumping stations either flare the gas or recompress it and inject it back into the pipeline.

In this paper we provide a solution whereby a microturbine is used to consume the leakage gas rather than flaring or reinjecting the gas.

NOMENCLATURE

CCHP	Combined Cooling Heat and Power
CHP	Combined Heat and Power
CO	Carbon Monoxide
HRM	Heat Recovery Module
NOx	Oxides of Nitrogen
VOC	Volatile Organic Compound
SO_2	Sulphur Dioxide
PM	Particulate Matter
ppmV	Parts per Million Volume
HAP	Hazardous Air Pollutant
GHG	Greenhouse Gas
TET	Turbine Exit Temperature
THC	Total Hydrocarbon

INTRODUCTION

In this paper, we use data from an existing underground gas storage facility connected to the electrical utility. Its pumping station receives gas at 50 bar. Using two 22 MW motor-driven compressors, the facility has an average leakage rate of approximately 20 m^3/h per compressor when in use [1].

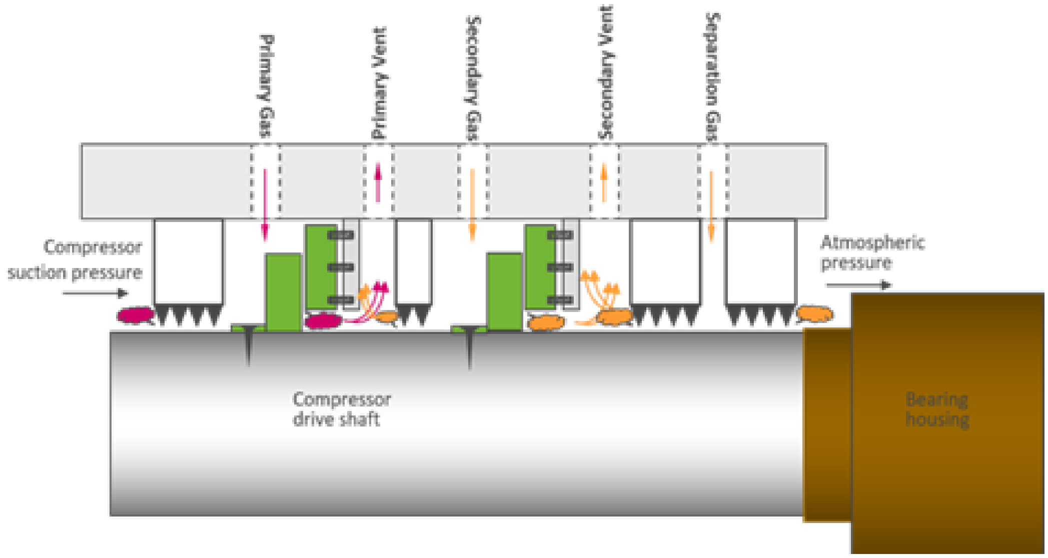

Figure 1: Typical Dry Seal. Source: Compressor Dry Gas Sealing Systems, Mark Dye, 2009

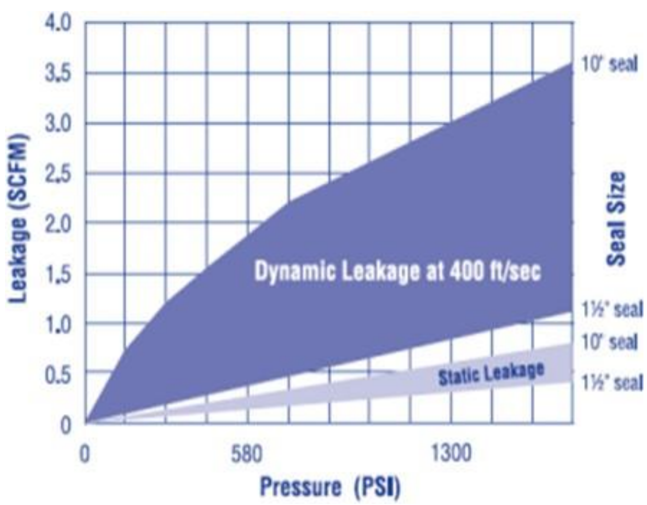

Figure 2: Typical Leak Rates of Dry Seals. Source: BW/IP International, Inc., Seal Division. Durco International and BW/IP International, known as Flowserve Corp.

An alternative to flaring the leakage gas or injecting it back into the pipeline is to let a microturbine consume the leakage gas as fuel. This has the following benefits:

- It reduces the need for flaring or venting leakage gas, lowering emissions. This becomes more important as stricter environmental policies require elimination of flaring.
- It reduces cost by eliminating equipment needed for compressing and injecting leakage gas into the pipeline.
- The microturbine can produce onsite/remote power with no fuel cost by burning leakage gas. Reduced utility/grid consumption provides additional cost savings.
- The exhaust energy of the microturbine can be used for CHP or CCHP to provide heated water and cooling for onsite use, resulting in total system efficiencies exceeding 80%. See Figure 3 for a dual microturbine installation that provides electrical power and heated water.

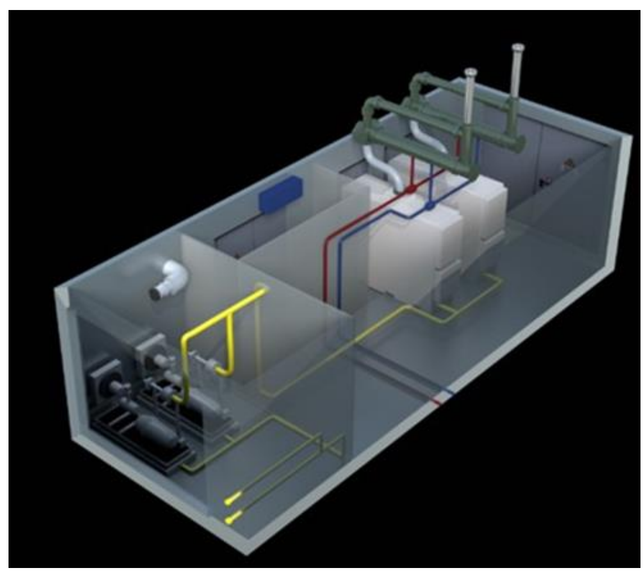

Figure 3: Microturbine Skid with HRMs. Source: Capstone Turbine Corp.

Alternatively, pipeline gas can be used to supplement the leakage gas, allowing the microturbine to continuously operate while consuming the leakage fuel. In applications where the gas leakage rate is less than the microturbine consumption, a buffer tank may be required. With this design, the microturbine has the ability to modulate the output load based on buffer tank pressure.

METHODOLOGY

In the methodology section, we compare emissions produced by flaring to those produced by a microturbine when consuming leakage gas. Next, we compare the cost of microturbine equipment to the cost of equipment needed for compressing and injecting the leakage gas into the pipeline. Finally, we examine the cost of using a microturbine to generate onsite power compared to utility usage or employing a diesel generator.

Flaring Vs Microturbine Consumption of Natural Gas

In this subsection we compare the level of emissions produced by flaring natural gas to the level of emissions from the exhaust of a Capstone microturbine burning natural gas.

Emissions from Flaring

Air pollutants associated with venting or flaring natural gas include, most prominently, methane and VOCs, as well as NOx, SO_2, PM, and various forms of HAPs. Methane, the principle component of natural gas is both a precursor to ground-level ozone formation (i.e. smog) and a potent GHG.

Low Emission Microturbine Technology

The emissions profile for a Capstone C65 microturbine, generating 65 kWe and burning natural gas, is shown in Figure 4 [2].

Pollutant	ppmV @ 15%
NOx	9
CO	40
THC	9
VOC	7

Figure 4: Microturbine Emissions Profile. Source: Capstone Turbine Corporation

Microturbine systems are inherently clean and can meet some of the strictest emissions standards in the world. However, fast and precise control of the combustion process is necessary to achieve low overall emissions. NOx formation diminishes as the combustion temperature declines, but a low combustion temperature results in higher emissions of CO and THC.

To resolve this conflict and achieve low NOx emissions simultaneously with low CO and THC emissions, combustion of the fuel must occur at the lowest possible temperature while the air and fuel mix remains in the combustion chamber long enough to combust most of the fuel, which is fulfilled in the microturbine. The NOx, CO and THC levels are at their lowest when operating at an output range between 90 and 100 percent.

Microturbine Equipment Cost

Microturbine capital costs range from approximately USD $650 to $1000/kW. These costs include all hardware, associated manuals, software, and initial training. Adding heat recovery increases the cost by USD $75 to $350/kW. Installation costs are much lower as microturbines do not require a concrete foundation surface and do not have any additional balance of plant [3].

Maintenance costs for microturbine units are based on forecasts with minimal real-life situations. They range from approximately USD $0.004 to $0.012 per kWh [4]. Figure 5 gives the frequency of service/overhaul time in running hours.

Overhaul	Hours
Replace air/electronics filters	8000
Replace air/electronics filters and igniter	16,000
Replace air/electronics/fuel filters and igniter, injectors. Inspect battery pack, liners and replace as necessary	24,000
Replace air/electronics filters	32,000
Replace air/electronics/fuel filters, igniter, injectors, battery pack. Inspect liners and replace as necessary. Replace frame and engine personality modules, enclosure fan, TET thermocouple, injectors/igniter, engine power head.	40,000

Figure 5. Microturbine Overhaul Schedule. Source: Capstone Turbine Corporation

CONCLUSION

With many initiatives being put forward worldwide to become greener, government and major oil and gas producers/operators are embracing flare reduction programs to reduce emissions and waste. Microturbines are an effective solution in helping operators become green by using flare gas to produce power and heat while eliminating emissions, contributing to a healthier environment, and improving bottom line in operational costs.

ACKNOWLEDGEMENT

REFERENCES

[1] Source Data for underground gas storage facility.
[2] Capstone Emissions Technical Reference (410065)
[3] Capstone Turbine Corporation
[4] Capstone Turbine Corporation