Vapor Recovery: Compliance and Profitability in Upstream OIL & GAS Production

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VAPOR RECOVERY
Market Brochure

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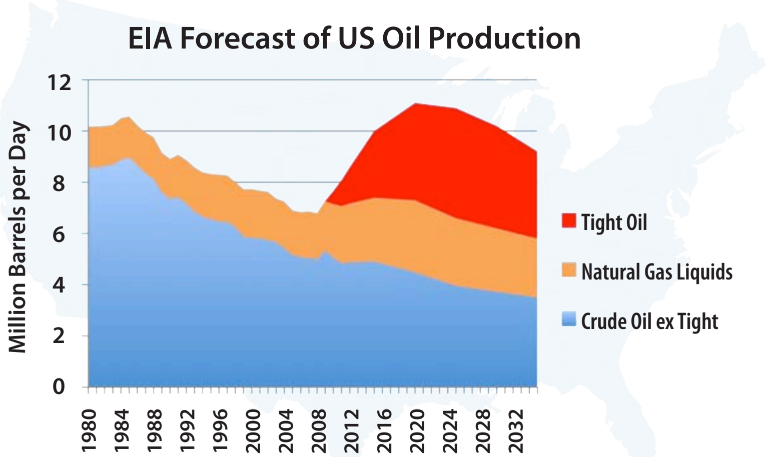
OIL-FREE RECIPROCATING
GAS COMPRESSORS

The U.S. Oil & Gas Boom is Real—and Permanent

Whether it's called a "boom," "golden age" or "new gold rush," there's no hiding from the undeniable fact that the recent surge in oil and gas production in the United States has been historic.



Source: EIA 2012 World Energy Outlook

There is no aspect of American life that will not be affected by this historic growth in oil and gas production, including the most basic. The facts, from both a micro and macro perspective, **don't lie.**

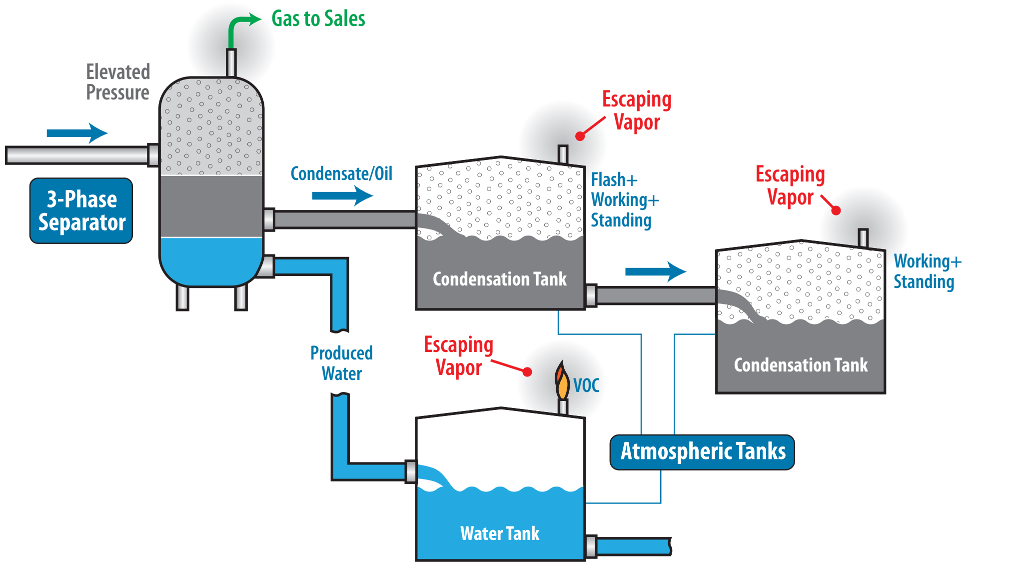
In 2013 the average daily domestic production of oil in the U.S. reached 7.5 million bpd (barrels per day). Levels not reached since the 1980's. Future EIA (U.S. Energy Information Administration) projections show that U.S. domestic oil production will continue to increase through at least 2019 and reach 9.6 million bpd.

Recent increases in production have been primarily driven by tight oil. In 2014, the EIA reported that oil production from the six prominent shale basins within the continental United States will reach 4.3 million bpd and together will account for 90% of the growth in U.S. oil production. By 2019, it is also projected that tight oil reserves will represent 51% of total U.S. production.

Vapor Recovery = A Regulatory and Economic Reality

There has always been an **economic** rationale for oil and gas producers to recover or prevent the emission of natural gas vapors into the atmosphere: any vapors that are either flared, vented or simply allowed to escape during the production and storage process—from wellhead to tank battery—are not saleable, or are viewed as not being worth the time and labor needed to reclaim them. In other words, not capturing as many oil and gas vapors as possible is akin to watching money (and potential profits) disappear into thin air.

In December 2012 the EIA reported that 17.5 Bcf of natural gas vapors per month were vented or flared into the atmosphere. That equates to 210 Bcf/yr of lost fuel product. In that same month, the commercial natural gas price was $9.75 per thousand cubic feet. Take that figure and apply it to the 210 Bcf of natural gas that were vented or flared during 2012, and you have a value for the lost natural gas vapors of **$2.05 billion** for the year.



Lost Vapor is **Lost Revenue**

Within the oil and gas custody, transfer and supply chain, there are a number of areas where valuable vapors may be flared off or simply allowed to escape to the atmosphere. Recovering these vapors will only add to the oil and gas producer's bottom line.

The Bakken Shale Play as seen from satellites.

CALL TO ACTION:

The simple fact is that if you are an oil and gas producer and you are not utilizing every measure available to optimize vapor recovery, you are watching potential profits float away.

The Regulatory Requirement for Vapor Recovery

In August 2011, the U.S. Environmental Protection Agency (EPA) introduced **New Source Performance Standard 40 CFR**, Part 60, Subpart OOOO, which has become known as the **"Quad O"** regulation. In October 2012, **Quad O** became law and began affecting oil and gas storage facilities, oil processing plants and gas wells across the country.

QUAD O TIMELINE

GROUP 1:
A storage vessel where construction, reconstruction or modification began after August 23, 2011 and before April 12, 2013.

GROUP 2:
A storage vessel where construction, reconstruction or modification began after April 12, 2013.

2011	2012	2013		2014	2015
August 23	October 15	April 12	October 15	April 15	April 15
EPA Quad O Rule in effect for **GROUP 1** production facilities constructed after this date but before April 12, 2013.	EPA Quad O becomes law and affects oil and gas storage facilities, natural gas processing plants and gas wells.	New facilities constructed after this date will have until April 15, 2014 or 60 days after startup, whichever is later, to install control equipment on their facilities.	Facilities must document number and GPS location of all storage tanks.	ALL **GROUP 2** storage tanks must be fully compliant with Quad O.	ALL **GROUP 1** storage tanks must be fully compliant with Quad O.

Quad O establishes emission standards and compliance schedules for the control of volatile organic compounds (VOC) and sulfur dioxide (SO_2) emissions from **storage tanks** at **tank batteries** that are used to temporarily hold liquids produced during the production of oil and natural gas. More specifically, Quad O includes a requirement that 95% of VOC emissions be contained, flared or reclaimed, and limited to less than six tons per year (tpy) from storage tanks that contain crude oil, condensate, produced water and other unrefined petroleum liquids.

While 6 tpy may sound like a lot, the daily equivalents for VOC emissions that would reach that level could be as low as:

- 33 pounds
- 1 million cubic feet
- 1 barrel of condensate
- 20 barrels of oil
- 2,000 barrels of water with 1% oil carryover

The deadline for all vessels, whether constructed, reconstructed or modified, that are used to store oil and natural gas to comply with the edicts of Quad O is April 15, 2015. This means that many oil and gas producers are rushing to identify and install vapor recovery equipment that can meet the VOC emission threshold of Quad O.

CALL TO ACTION:

The simple fact is that if you are an oil and gas producer and you are not aware of the effects that Quad O regulation will have on your operations, you are likely to run afoul of the EPA.

Normal photo of storage tank

Photo taken at the same time with a FLIR® GasFinder infrared camera shows the vapors that are escaping

That's Not All

While Quad O may be the most high-profile attempt by the EPA to force oil and gas producers and handlers to control their VOCs, there is a wide array of federal and state regulations that also govern the vapor recovery process.

Here are two examples of what oil and gas producers must deal with in regards to vapor recovery:

- *In November 2010, the EPA created the Greenhouse Gas Reporting Program's "Subpart W" rule, which states that "owners and operators of facilities that contain petroleum and natural gas systems and emit 25,000 metric tons or more of greenhouse gases (GHGs) per year report that GHG data to the EPA." What Subpart W did, starting in 2013, oil and gas producers must report any equipment leaks or vented/flared carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions. A level of 25,000 metric tons per year is equivalent to 170,000 cubic feet per day of methane.*
- *From a state perspective, since 1991 the Texas Commission of Environmental Quality (TCEQ) has mandated that "storage tanks storing crude oil, natural gas or condensate prior to custody transfer or at a pipeline breakout station must route flashed gases to a vapor recovery system or control device if the uncontrolled VOC emissions from an individual storage tank, or from the aggregate of tanks in a tank battery, have the potential to exceed 25 tons per year on a rolling 12-month basis."*

Vapor Recovery Units: An Acceptable Method of Routing Emissions

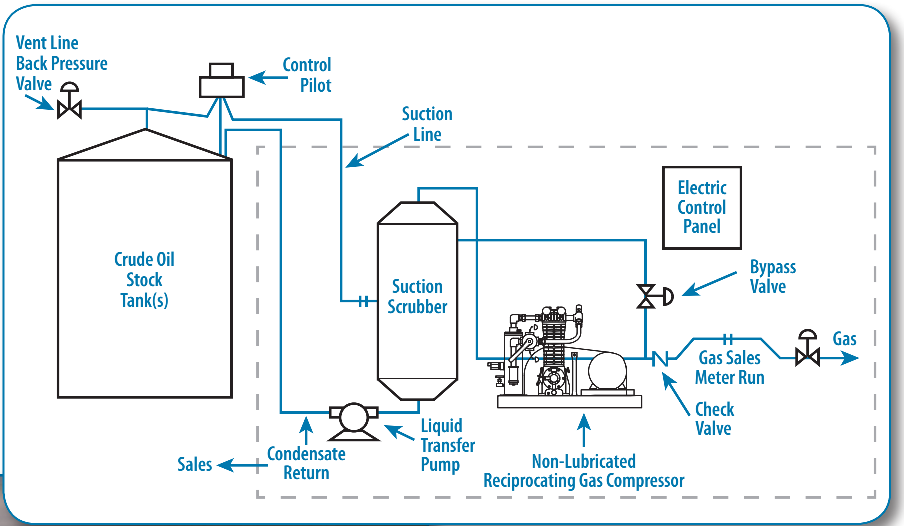
The EPA has stated that the use of Vapor Recovery technologies such as VRU's are a cost-effective and proven method to capture and sell oil and gas vapors that currently escapes into the air. In fact, they concur that it is a system that more than pays for itself.

The Agency even goes so far as to identify the Vapor Recovery Unit (VRU) as a critical component to be used in optimizing the collection, recovery and reclamation of oil and gas vapors:

*"We agree **it is better to recover resources than burn them** and VRUs are an acceptable method of routing emissions back to the process. We really consider them part of the process, rather than an add-on control."*

How a VRU Works

(Simple Stock Tank Example)



Making the Most of Vapor Recovery

If an oil and gas storage-tank battery emits 530 tons of VOCs per year, that is 55,000 standard cubic feet per day (Mscfd). At a rate of $4 per Mscfd, and with an Mscf equivalent to 2,000 BTUs, that is $132,000 in lost revenue per year—per storage vessel. If the installation of a Vapor Recovery Unit costs $100,000, the operator will recoup his investment in **nine months**.

Compressors Help Drive VRU Operation

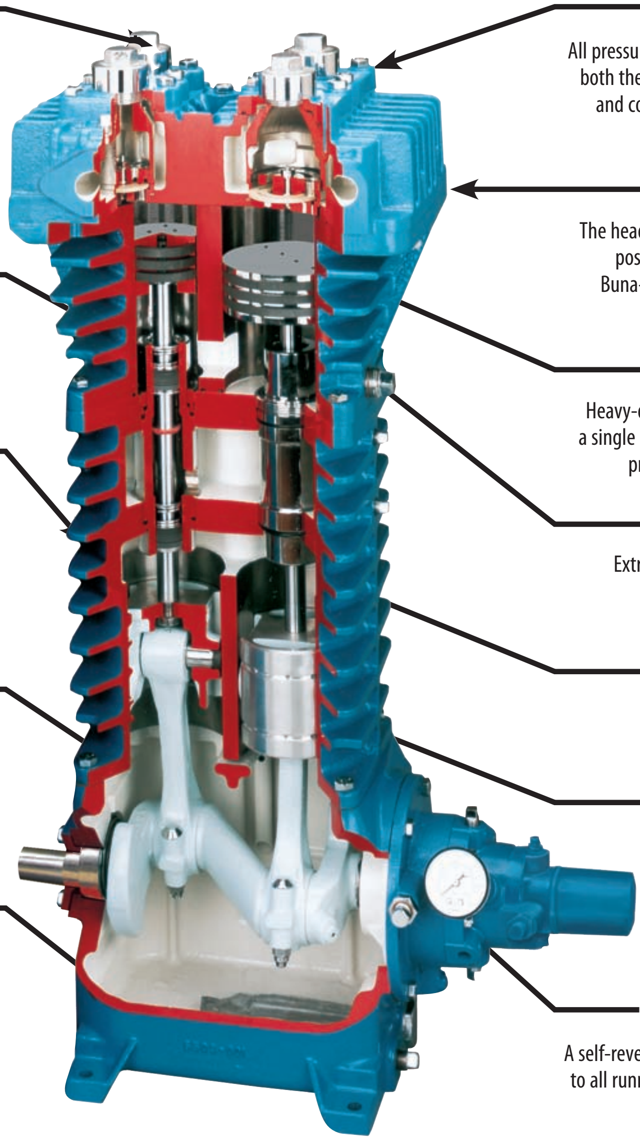
Vapor Recovery Units (VRU) that are used on storage vessels in oil and gas control, containment and reclamation at tank batteries are just that, "units" consisting of various components that are designed and assembled together by an OEM or fabricator in order to create a completed VRU.

One of the most important components on the VRU is the **Compressor** that is used to efficiently and effectively capture, control and transfer the oil and gas vapors to the storage tank. Recognizing the untapped potential for improved vapor recovery in the field, Blackmer® has designed a complete family of **Oil-Free Reciprocating Gas Compressors** that offer a wide range of operational features for enhanced vapor recovery.

Single or **Double** Distance-Piece Design

Oil and gas vapors are only usable or saleable if they remain uncontaminated during their collection. To combat potential contamination of the natural gas stream from any oil that is present, Blackmer has designed its compressors with a single or double distance piece that is located between the compressor's cylinder and crankcase and protected by two sets of piston-rod seals. The distance pieces, create a compartment that prevents vapor leakage into the atmosphere and prevents oil leakage and resulting contamination of the crankcase. The ports within the distance piece can each be independently purged, pressurized or vented for maximum containment of toxic and hazardous VOCs before they can escape to the atmosphere.

The inside view on why **Blackmer Compressors** are superior in handling wellhead gases and controlling vapor emissions



High efficiency, PEEK valves

Blackmer valves are specifically designed for oil-free gas applications. Standard valve plates are constructed of self-lubricating PEEK (Poly Ether Ketone) material that provides superior sealing characteristics, high efficiency and durability. Optional stainless steel valves are also available. Note: Series HD160 and HD170 have TNT-12 impregnated steel valves.

Live loaded piston rod seals

Filled PTFE seals are wear compensating and maintain a constant sealing pressure around the piston rods with minimum friction. This special seal design prevents crankcase oil contamination and cylinder blow-by.

Single or double-distance piece

Single or double distance pieces (isolation chambers), control contamination of the compressed gas from crankcase lubricant, even at high vacuum inlet conditions. Each isolation chamber may be independently purged, pressurized or vented for maximum containment of toxic or hazardous gases.

Heavy-duty precision ground crankshaft

The ductile iron crankshaft features roller bearings and integral counterweights for smooth, quiet operation. Rifle drilling ensures positive oil distribution to the wrist pin and connecting rod bearings.

Two-part epoxy paint

ANSI flanges

Many models are available with ANSI flanges for compatibility with CPI and refinery industry standards.

Ductile iron construction

All pressure parts are ductile iron for greater resistance to both thermal and mechanical shock. For extended wear and corrosion resistance, specify the TNT-12 PTFE and Nickel impregnation option.

O-ring seals

The head and cylinder are sealed with O-rings to ensure positive sealing under severe operating conditions. Buna-N, FKM, Neoprene, PTFE or Ethylene-Propylene O-rings are available.

One piece piston

Heavy-duty steel pistons are connected to the rod with a single positive locking nut, which eliminates potential problems associated with multiple piece designs.

Self-lubricating piston rings

Extra-thick, self-lubricating filled PTFE piston rings provide more wear surface for maximum sealing and extended life.

S3R Seal (600/900 Series)

Enhanced oil control providing even greater leakage control.

Wrist pin needle bearings

Roller needle bearings provide longer life under high rod load applications. Superior wrist pin lubrication is assured under all load conditions. All HD/HDL/HDS compressors are free of yellow metals.

Pressure lubricated crankcase

A self-reversing oil pump provides positive oil distribution to all running gear components for long life and minimal wear. A full-flow spin-on oil filter is standard.

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Blackmer® Oil-Free Reciprocating GAS COMPRESSORS for Use in Vapor Recovery

The following two charts illustrate the inherent benefits offered by Blackmer's family of **Oil-Free Reciprocating Gas Compressors** on numerous performance criteria when compared to other compressor technologies available for inclusion in the construction of a Vapor Recovery Unit.

Compressor Solutions Comparison

Compressor Type	Gas Recovery Capability	Containment	Maintenance	Protection From Condensate Contamination	Reliability	Handles Variations in Flow Volumes	Handles Variations in Pressures	Distance Piece	Drive Design
Non-Lubricated Reciprocating	**Yes**	**Very High**	**Low**	**Very Good**	**Good**	**Good**	**Very Good**	**Yes**	**Belt**
Lubricated Reciprocating	Yes	Low	Medium	Very Low	Very Low	Good	Very Good	No	Belt
Rotary Vane	Yes	Medium	Medium	Low	Low	Very Good	Very Low	No	Direct
Rotary Screw	Yes	Medium	Very Low	Medium	High	Very Good	Good	No	Direct
Rotary Scroll	Yes	High	Low	Medium	High	Good	Good	No	Direct

Compressor Solutions Comparison

Compressor Type	Gas Filter/ Separator	Leakage Control	Frequency of Oil Changes	Mechanical Efficiency	Application Flexibility	Oil Cooling	Ease of Maintenance	Modular Design
Non-Lubricated Reciprocating	**No**	**Yes**	**Less**	**Very High**	**Very High**	**Not Required**	**Very Good**	**Yes**
Lubricated Reciprocating	No	No	High	Very High	Very High	No	Very Good	Yes
Rotary Vane	Yes	No	High	High	Low	Required	Low	No
Rotary Screw	Yes	No	High	High	Good	Required	Low	No
Rotary Scroll	Yes	Yes	Low	High	Low	Required	Low	No

Blackmer offers three models of Oil-Free Reciprocating Gas Compressors for inclusion on Vapor recovery Units at storage tank batteries.

NG Series

NG Series compressors are available in a wide range of small frame sizes that make them an ideal fit for small to mid-size tank batteries that require a VRU.

Features & Benefits

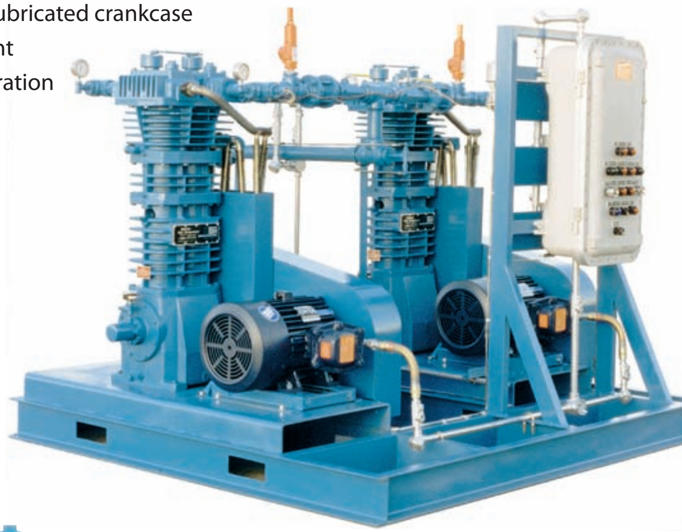
- Maximum control of fugitive emissions
- Minimum friction
- Full distance-piece design
- Ductile-iron head and cylinder construction
- O-ring head gaskets for positive sealing
- One-piece steel piston
- Piston rod attached with one positive locking nut
- Self-adjusting PTFE piston rods
- Pressure-lubricated crankcase
- Self-reversing oil pump driven by crankshaft
- External oil filter
- Epoxy paint

HD Series

HD Series compressors provide efficient delivery of oil-free natural gas through the use of advanced design technology and state-of-the-art materials.

Features & Benefits

- Ductile-iron construction
- Single-stage or two-stage configurations
- Air-cooled or liquid-cooled options
- Single-, double- or triple-seal construction
- Full distance-piece design
- Ports for purging, pressurizing or venting in each distance piece
- Head/cylinder sealed with O-rings
- Two sets of piston-rod seals
- Can handle toxic, hazardous or corrosive gases
- Pressure-lubricated crankcase
- Epoxy paint
- Quiet operation

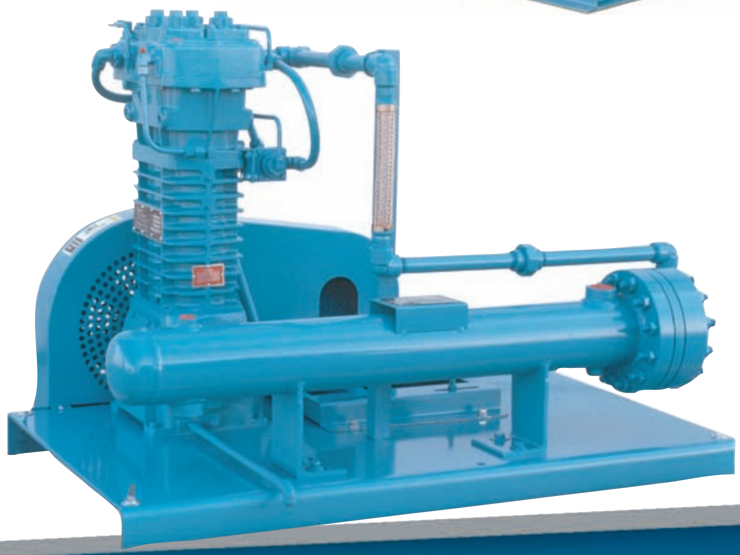


HDS Series

HDS Series compressors have been designed for installation in vapor recovery units that are used in sour-gas transfer and storage applications.

Features & Benefits

- Single- or two-stage models available
- Stainless-steel fasteners in all gas-containment areas
- Ductile-iron head and cylinder
- Extra-thick piston rings for greater ring life
- O-ring head gaskets for positive sealing
- Single distance-piece construction
- One-piece steel pistons attached to piston rod via one positive locking nut
- Flanged connections for piping flexibility
- Self-adjusting piston-rod seals
- Pressure-lubricated crankcase
- Self-reversing oil pump driven by crankshaft
- Spin-on oil filter



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