Oilfield Compression 101

August 11, 2020

Presentation Items

A. Compressor Applications

- Casing Gas
- Vapor Recovery
- Gas Well Boosting

B. 7 Types of Compressor

- Reciprocating
- Oil Flooded Screw
- Sliding Vane
- Blower
- Hydraulic
- Multiphase Transfer Pump
- Wet Gas

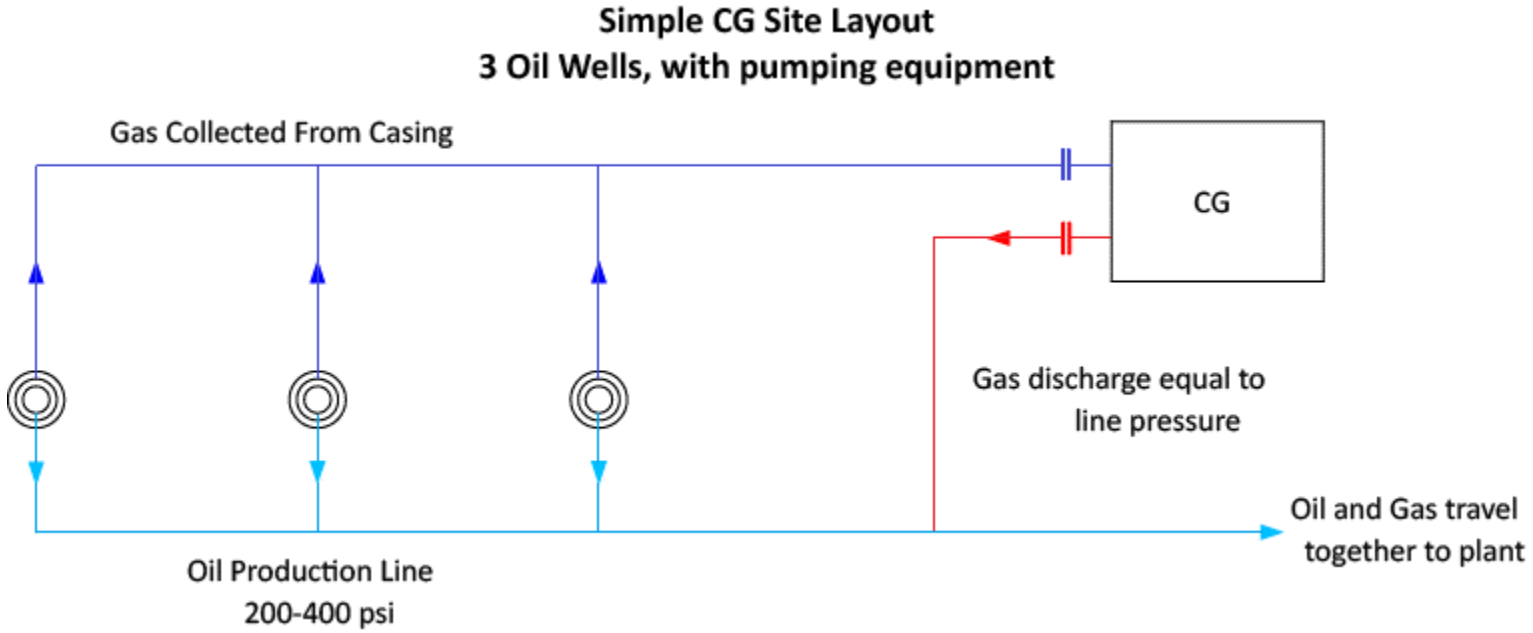
C. 4 Types of Driver

- Gas Engine
- Electric Motor
- Diesel Engine
- Hydraulic Motor

Casing Gas

Typical Operating Conditions

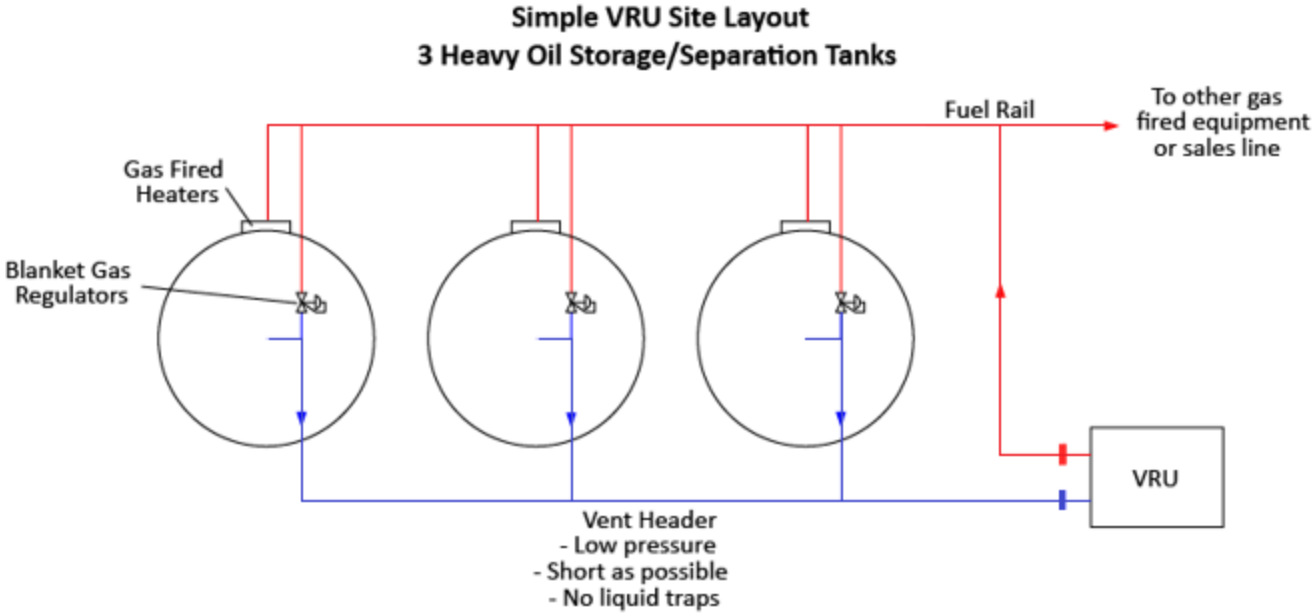
- Suction 15-40 psi/100-275 kPa
- Discharge 150-400 psi/1000-2800 kPa
- Water saturated gas stream
- Mostly methane, with some longer chain hydrocarbons



Vapor Recovery

Typical Operating Conditions

- Suction 0-1 psi/0-7 kPa
- Discharge 40-150 psi/275-1000 kPa
- High CO_2 content, frequently some H_2S content
- Water saturated gas stream
- Large range of hydrocarbons, short chain and long chain

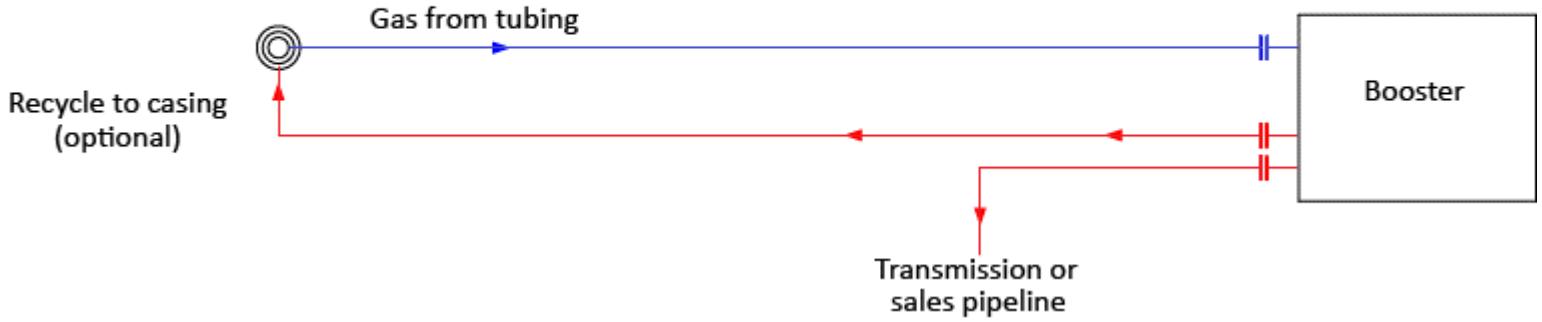


Gas Well Boosting

Typical Operating Conditions

- Suction 0-50 psi/0-340 kPa
- Discharge 60-300 psi/410-2070 kPa
- Gas stream is primarily saturated methane, may have some sour content

Simple Booster Site Layout
Single Gas well with Casing Recycle

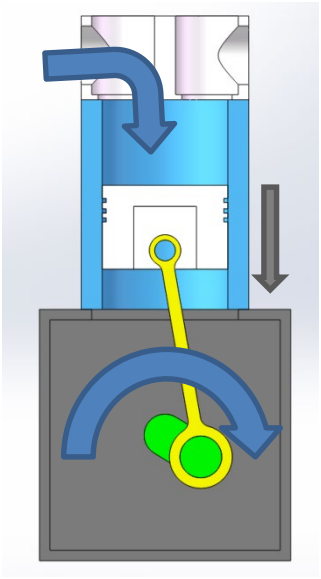


Reciprocating Compressor

- Oldest, most extensively developed style of compressor
- Uses a piston traveling back and forth to expand and contract compression chamber volume
- Depends on check valves to permit flow in only one direction
- Three common styles: Air derivative, process gas, field gas
- Two common types: single-acting or double-acting

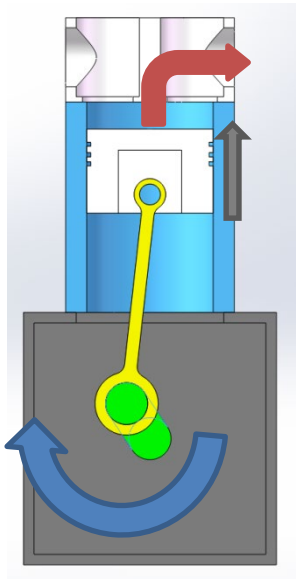
Suction

1. Piston travels down
2. Discharge valve closes
3. Pressure drops below suction pressure
4. Inlet valve opens
5. Chamber fills with suction pressure



Discharge

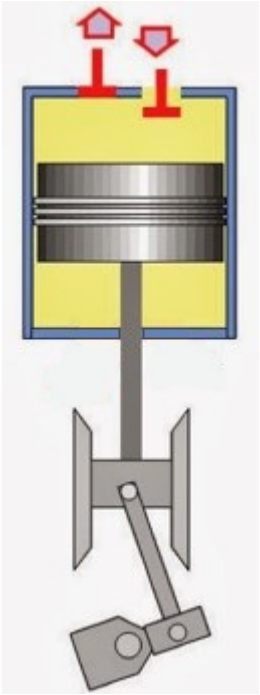
1. Piston travels up
2. Inlet valve closes
3. Chamber pressure increases to discharge P
4. Discharge valve opens
5. Gas is forced out as chamber volume decreases



Single-Acting vs Double-Acting

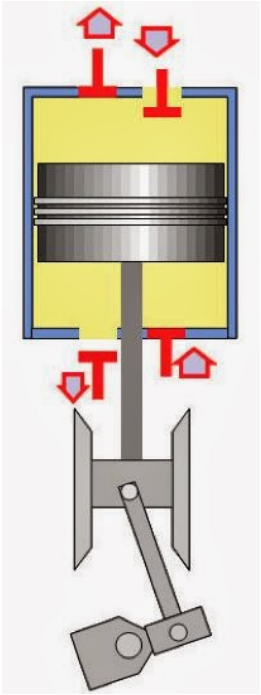
Single-Acting

- Valves at one end of cylinder
- One suction/discharge cycle per piston stroke
- Simpler design



Double-Acting

- Valves at both ends of cylinder
- Two suction/discharge cycles per piston stroke
- More efficient



Stages

- Compressors with multiple cylinders can use two or more compression stages for a higher overall compression ratio

Single Stage

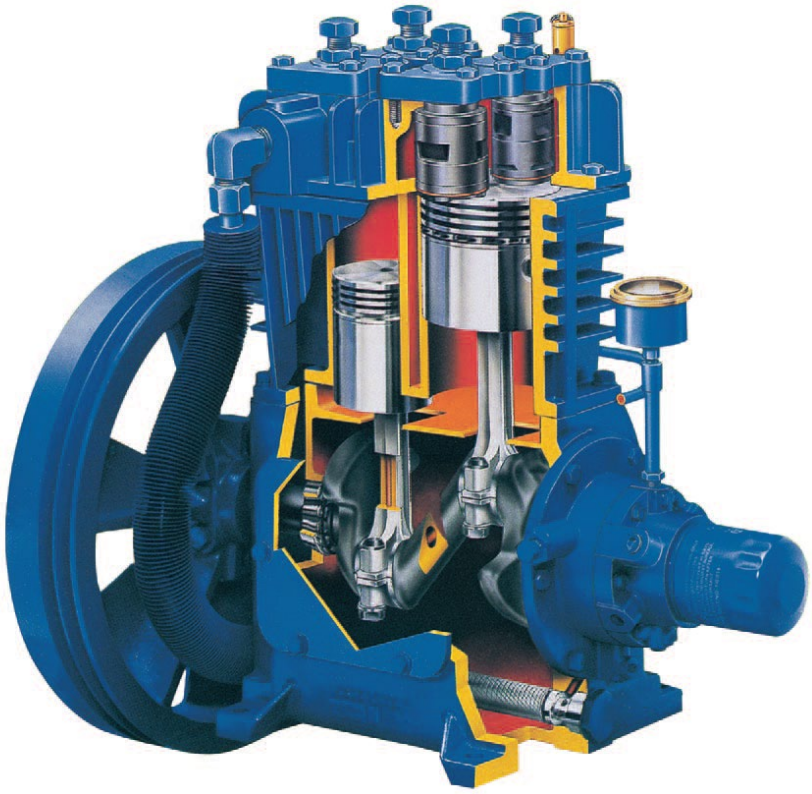
- One or more cylinders
- Each cylinder at same suction and discharge pressure
- Higher volume of gas moved

Multistage

- At least two cylinders
- Each successive cylinder's suction is the previous one's discharge
- Higher overall compression ratio
- Usually requires cooling between stages
- Multistage compressor systems need not be recip only, ie can use a screw or blower to boost initial pressure for a recip

Air Compressor Derivative

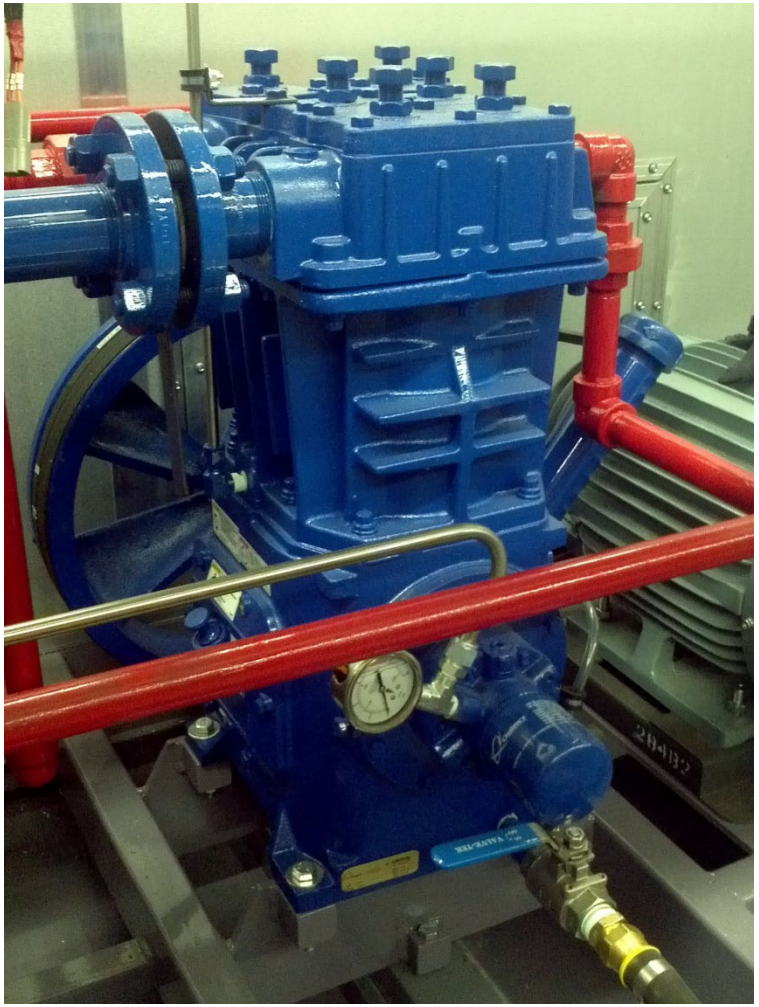
- Vertical single, vertical twin, or V-twin
- Single-acting
- 1 or 2 stage
- Crankcase oil lubricated



Quincy Cutaway

Air Compressor Derivative

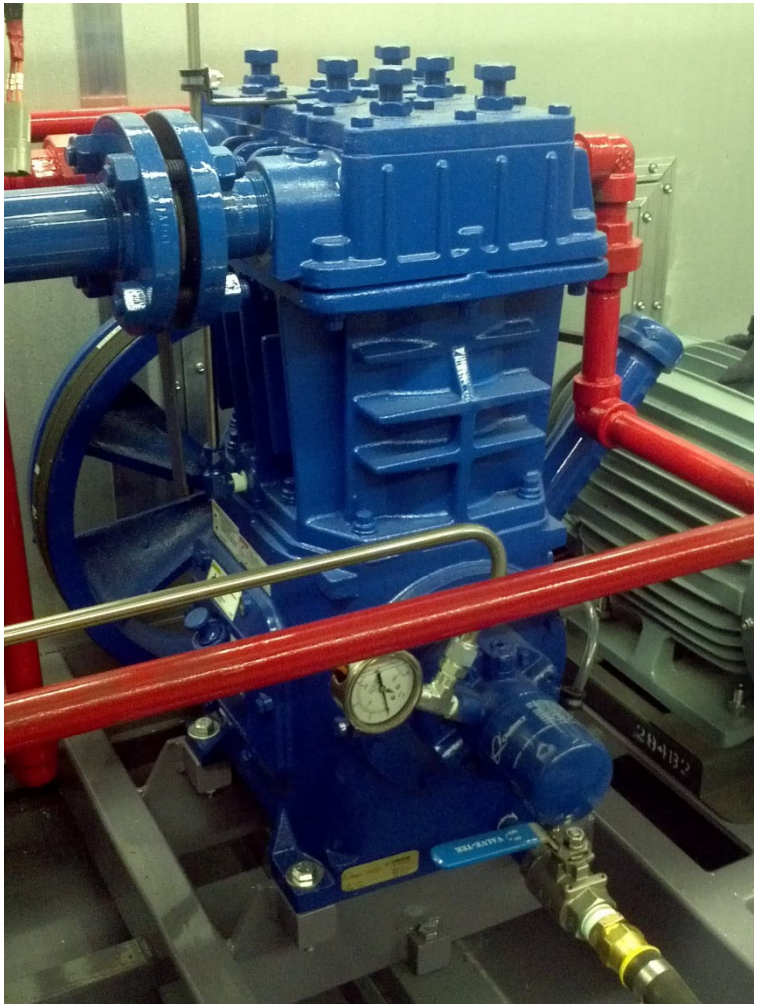
- 5-30 hp/3.7-22 kW
- Suction 0-50 psi/0-345 kPa
- Discharge 10-400 psi/70-2800 kPa



Quincy 370 in CG25

Air Compressor Derivative

- Over the years a number of packagers have used Air Compressor derivatives for low volume natural gas service primarily because they are much less expensive than Process Gas Compressors
- Because they were designed for air – not natural gas – they have a number of design factors including continuous venting that make them unsuitable for most NG applications



Quincy 370 in CG25

Air Compressor Derivative

Advantages

- Low capital cost
- Compact, small footprint

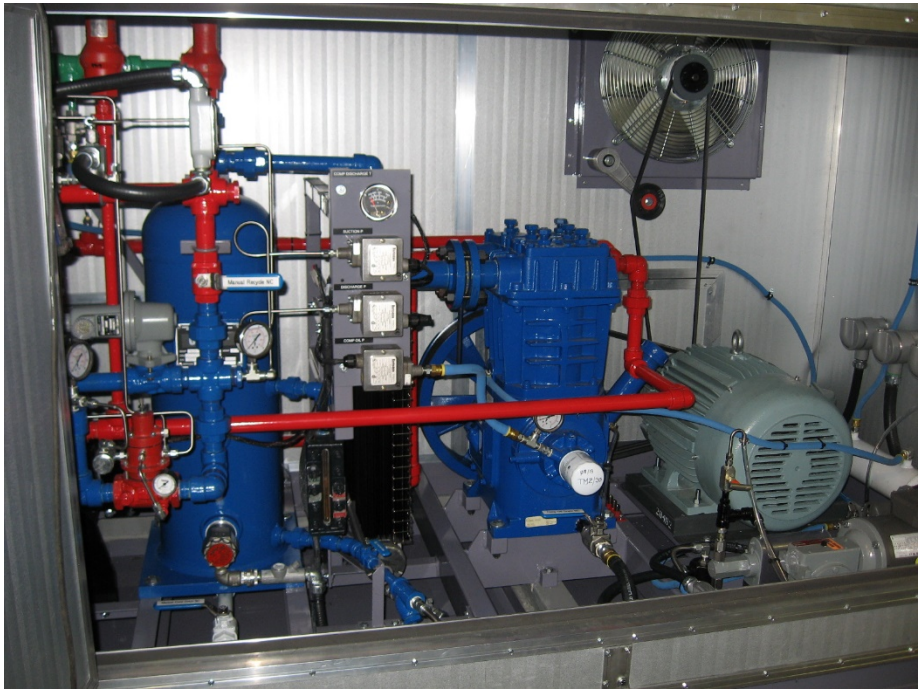
Disadvantages

- Designed for air – not NG
- Continuous venting
- Regular maintenance required, oil changes, valve replacements
- Less flexible to changing capacity, limited range of operating speeds
- Have to manage vibration with specialized mounting

Air Compressor Derivative

Preferred Applications

- Casing gas
- Low volume gas well boosting
- Vapor recovery requiring high discharge pressures

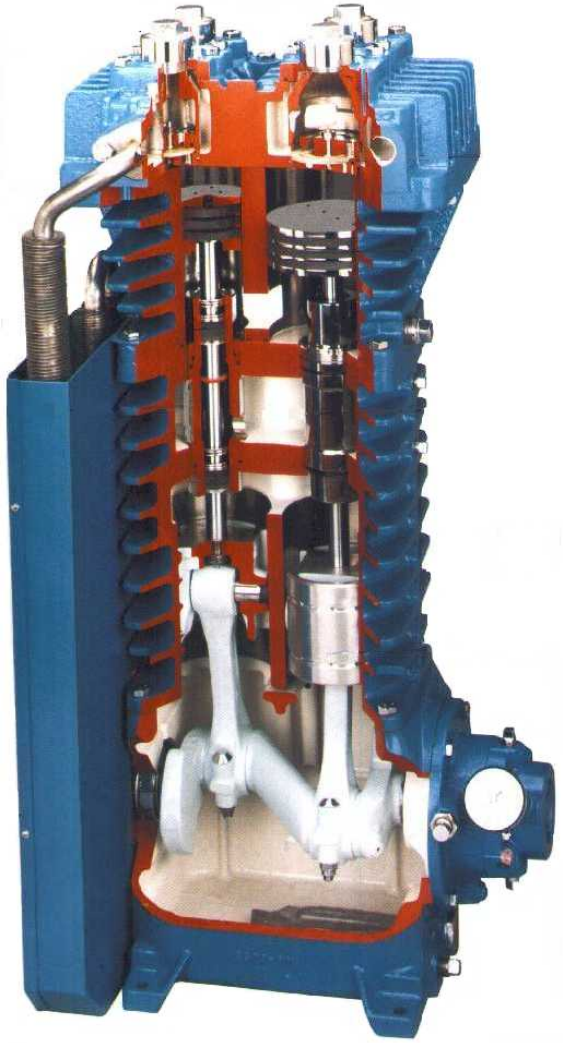


Quincy QR370NG in CG25

Vertical Frame Reciprocating

(Process Gas)

- Small frame, vertical twin
- Single-acting or double-acting
- One or two stage
- Distance pieces isolate crankcase from process gas
- Crankcase oil lubricated



Blackmer Cutaway

Vertical Frame Reciprocating

(Process Gas)

- 5-40 hp/3.7-30 kW
- Suction 0-40 psi/0-275 kPa
- Discharge 50-1000 psi/345-6900 kPa

Blackmer LB361

Vertical Frame Reciprocating

(Process Gas)

Advantages

- Compact, small footprint
- Can be specified with corrosion resistant materials for H_2S service

Disadvantages

- Regular maintenance required, oil changes, valve replacements
- Less flexible to changing capacity, limited range of operating speeds
- Have to manage vibration with specialized mounting
- High capital cost/capacity

Vertical Frame Reciprocating

(Process Gas)

Preferred Applications

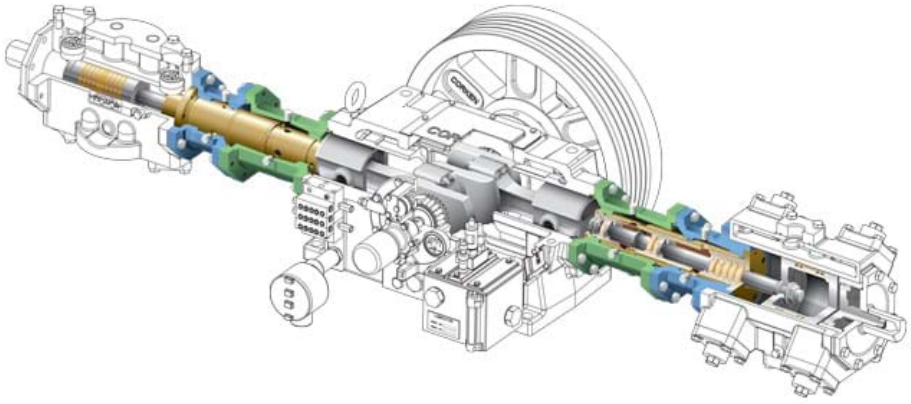
- Casing gas
- Low volume gas well boosting
- Vapor recovery requiring high discharge pressures

Blackmer HDS612C in CG30 2-stage sour compressor

Horizontal Frame Reciprocating

(Conventional NG Compression)

- 1 to 4 stages
- 2/4/6 cylinders, horizontally opposed
- Single or double-acting
- Can have multiple stages on one cylinder in a “steeple” formation
- Crankcase oil lubrication, and pumped oil injection at bearings and bushings

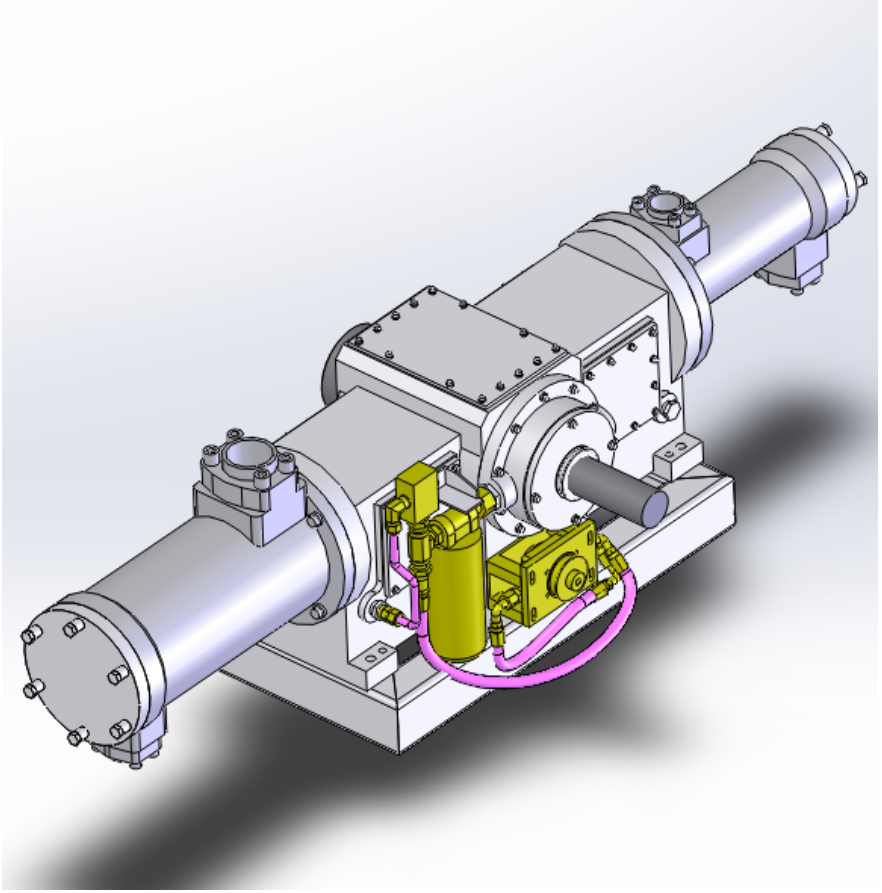


2 throw, 2 stage balanced horizontal frame recip

Horizontal Frame Reciprocating

(Conventional NG Compression)

- 75-4000 hp/56-3000 kW
- Suction 0-500 psi/0-3450 kPa
- Discharge 50-3000 psi/ 345-20700 kPa



CIP 2 throw balanced horizontal frame recip

Horizontal Frame Reciprocating

(Conventional NG Compression)

Advantages

- The only option for discharge pressures above 1000 psi/ 6900 kPa
- Can specify different cylinders for a given frame, to fine tune to the application
- Can reconfigure for different applications
- Can specify corrosion resistant materials for H_2S service

Disadvantages

- High capital cost
- Require regular maintenance, valves, oil changes, rebuilds
- Large footprint
- Limited flexibility to changing conditions in the field
- Pressure pulsation needs to be controlled
- High vibration – requires heavy (cement) base

Horizontal Frame Reciprocating

(Conventional NG Compression)

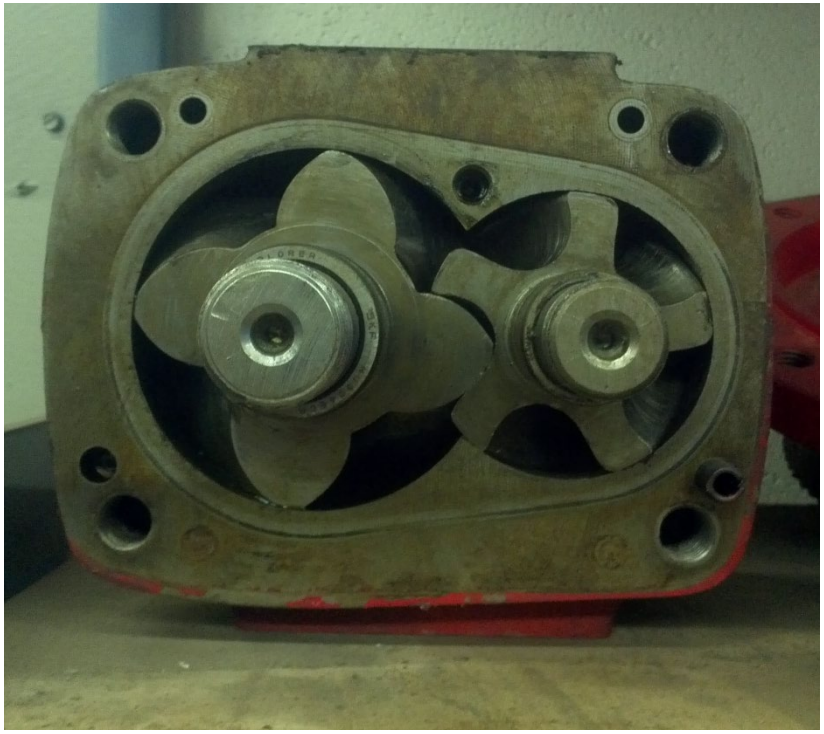
Preferred Applications

- Anything requiring very high discharge pressure
- High volume + high pressure casing gas

CIP PVT JR in CC75R

Oil Flooded Screw

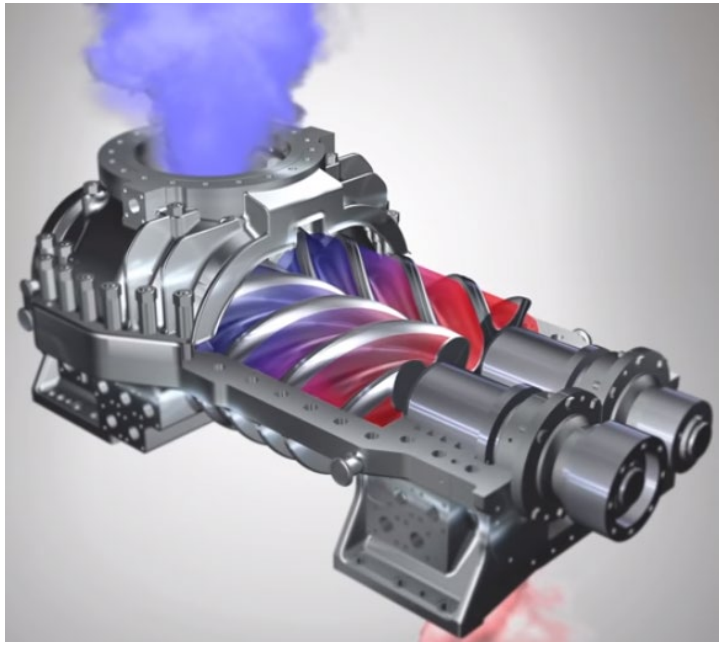
- Rotating helical screws mesh and unmesh to open and close compression volumes
- No valves
- Oil is injected to lubricate, seal and cool the compressor



Tamrotor E6

Oil Flooded Screw

- Single stage
- 5-500 hp/3.7-375 kW
- Suction 0-70 psi/0-480 kPa
- Discharge 50-500 psi/345-3450 kPa
- High flow rate recycling oil lubrication



Rotary Screw

Oil Flooded Screw

Advantages

- Very flexible to changing conditions, can vary speed across a broad range
- No regular maintenance, just add oil and change filters as needed
- Low capital cost of compressor itself
- Lightweight
- Compact

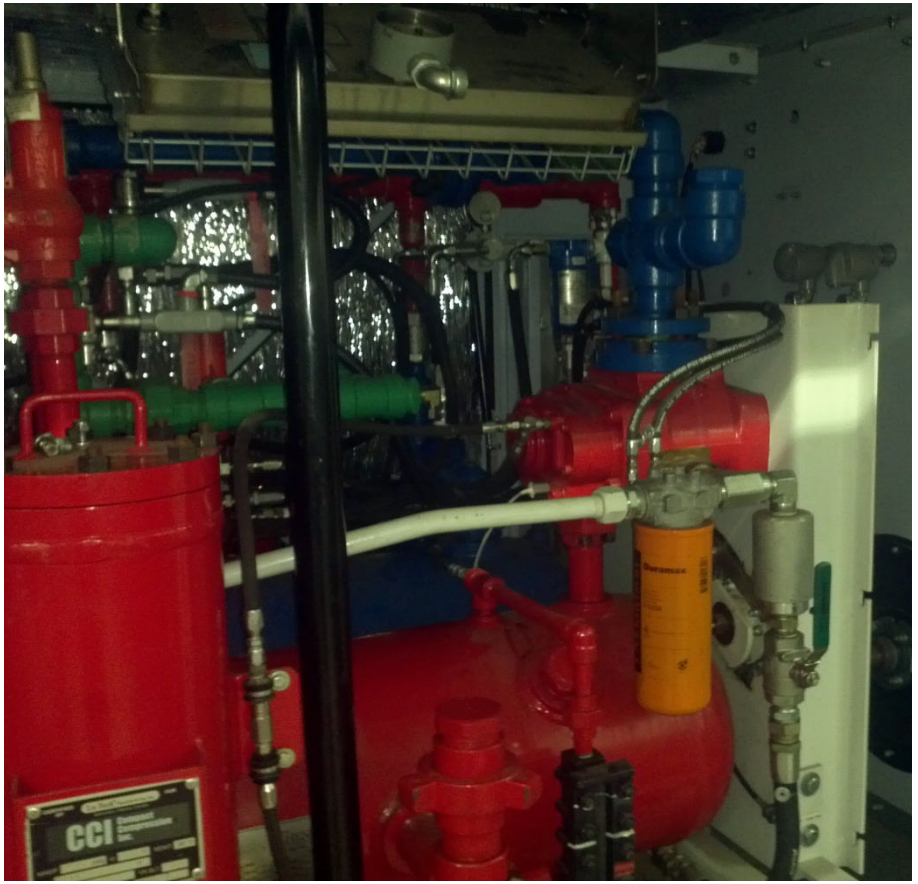
Disadvantages

- Can be vulnerable to oil dilution
  - Dry NG gas requires polyglycol (PAG) oil, because its mechanical and heat transfer properties allow the longest life for both oil and compressor, and it is resistant to dilution by natural gas molecules
  - Wet gas contains long chain hydrocarbons ("long ends") that, in liquid state, can dilute PAG oil, ruining its ability to lubricate – change oil regularly (expensive) or destroy compressor (more expensive)
  - Can compensate for this by increasing oil temperature to keep some long ends in a gas state, reducing their solubility – this is a patch and not always effective
- Minimum discharge pressure is required to keep oil circulating
- Oil and oil separation equipment add to capital cost

Oil Flooded Screw

Preferred Applications

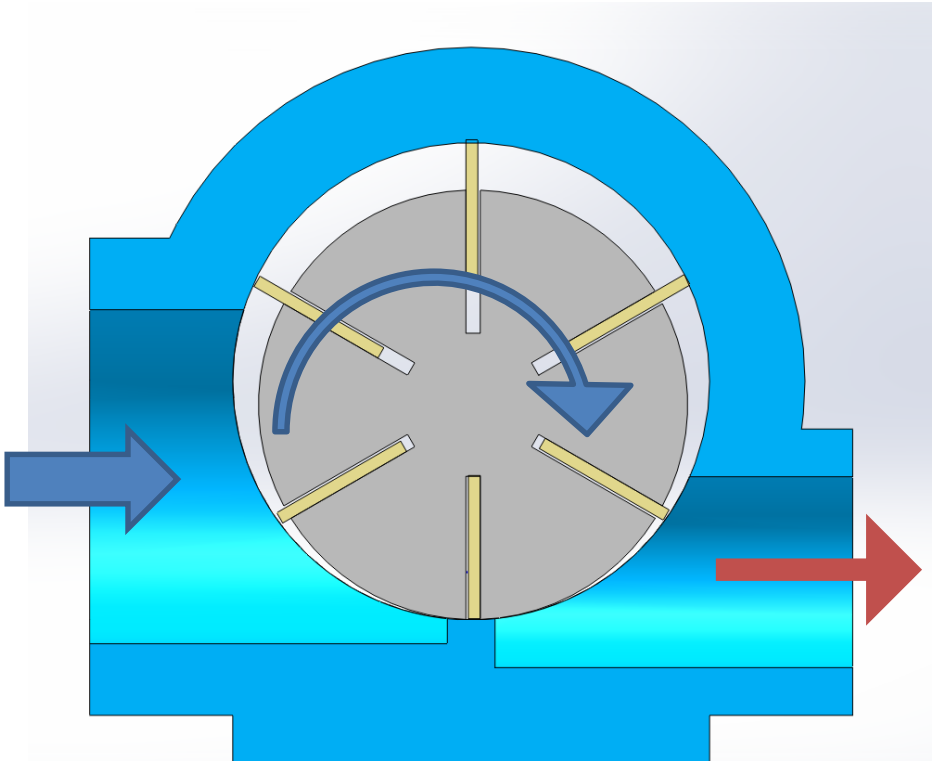
- Mobile/Trailer mounted compressors
- Test compressors
- Gas well boosting
- Vapor recovery (dry gas)



Tamrotor E12 in CC50

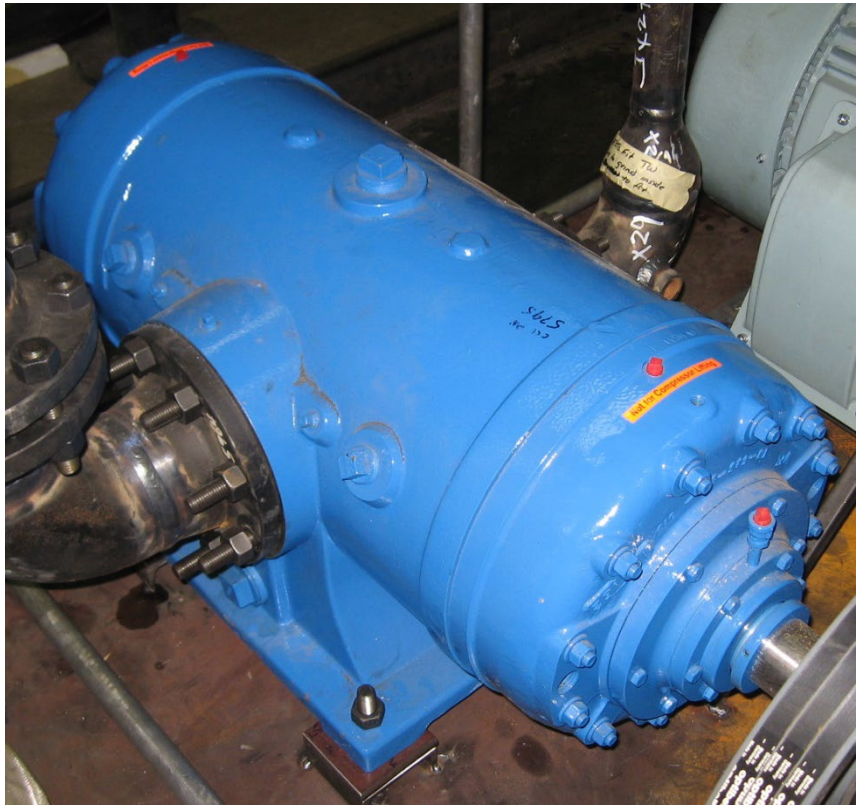
Sliding Vane

- Eccentric rotor turns in cylindrical housing
- Vanes are held tight to housing walls by centrifugal force
- Rotation and sliding of vanes opens and closes volume pockets
- Oil injected to lubricate vanes and bearings
- No Valves



Sliding Vane

- 1 or 2 stage
- 5-380 hp/3.7-285 kW
- Suction 0-100+ psi/0-690+ kPa
- Discharge 0-150 psi/0-1030 kPa
- “Once through” oil lubrication – once injected oil is discarded to process



Ro-Flo 10G in CV75E

Sliding Vane

Advantages

- Very resilient to corrosion – can work on up to 90% H_2S
- No issues with lubricant dilution
- Regular maintenance items are inexpensive, with long maintenance intervals
- Can tolerate a small amount of liquid ingestion, good for service that sees long chain hydrocarbons
- Good range of operating speeds

Disadvantages

- Oil injected into compressor is not recovered, must continually replenish oil supply – extra cost
- Limited to pressures below 150 psi/1030 kPa
- External lubrication and coolant systems add to cost and complexity

Sliding Vane

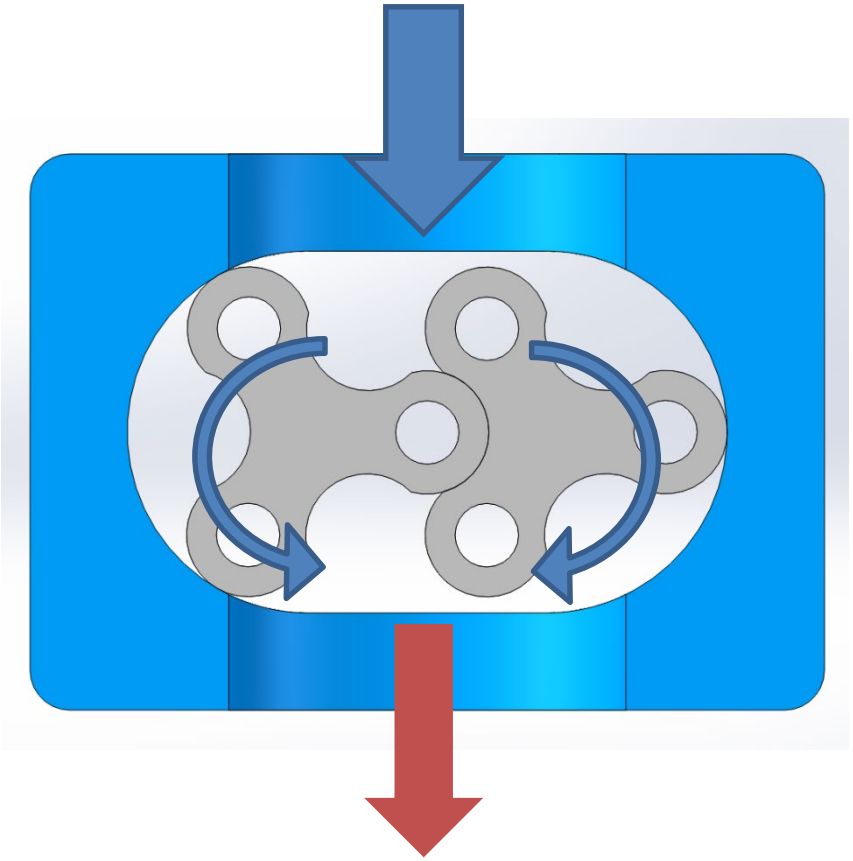
Preferred Applications

- Best option for high-volume corrosive or liquid rich service
- Vapor recovery (dry gas)
- Trailer mounted compressors

Roflo 4CC in CV20

Roots Blower

- Lobes intermesh to open and close volume pockets
- Timing gears keep lobes synchronized. They run at close tolerances but never contact
- Lobes may be straight cut or helical
- No oil or lubricant in contact with process



Roots Blower

- Single stage
- 2-100+ hp/1.5-75 kW
- -15” Hg to 10 psi/69 kPa suction
- Up to 20 psi/137 kPa discharge
- Timing gears and bearing independently lubricated, sealed off from process

Dresser Roots URAI 59

Roots Blower

Advantages

- Oil free discharge
- Minimal maintenance
- No internal compression, less sensitive to entrained liquids
- Inexpensive

Disadvantages

- Must maintain high speed for high discharge pressure, limiting flexibility
- Low maximum discharge pressure
- Low efficiency
- Capacity control is difficult – limited turndown range

Roots Blower

Preferred Applications

- Vacuum suction pressure
- Low pressure VRU
- Use as 1st stage before a recip to increase flow rates

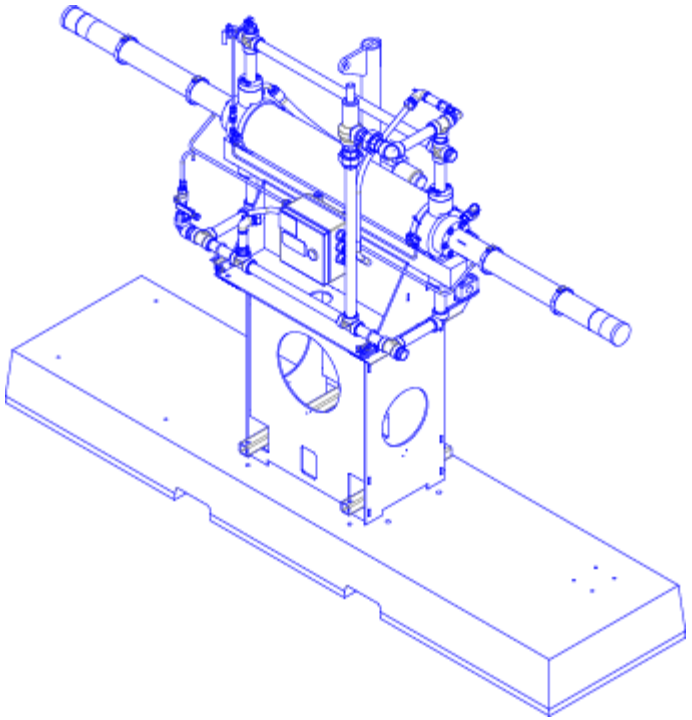
Hydraulic

- Single-stage, double-acting reciprocating compressor
- Hydraulic rams provide motive power
- Slow speed and long stroke
- Able to process large quantities of liquids through the compression element

HCG15 - 613

Hydraulic

- Single stage
- 15 – 50 hp/11 – 37 kW
- Suction 0-1200 psi/0-8300 kPa
- Discharge up to 1200 psi/8300 kPa
- Up to 380 psi/2620 kPa ΔP



HCG15 - 613

Hydraulic

Advantages

- Able to process large quantities of liquid through the compression element
- Self-regulating control system
- Fit-for-purpose design for casing gas applications
- Easily field serviceable
- Designed for high H_2S concentrations (usually increase corrosion allowance on plumbing)
- Low capital cost
- 100% turndown

Disadvantages

- Hydraulic oil requires periodic replenishment
- Pulsating flow

Hydraulic

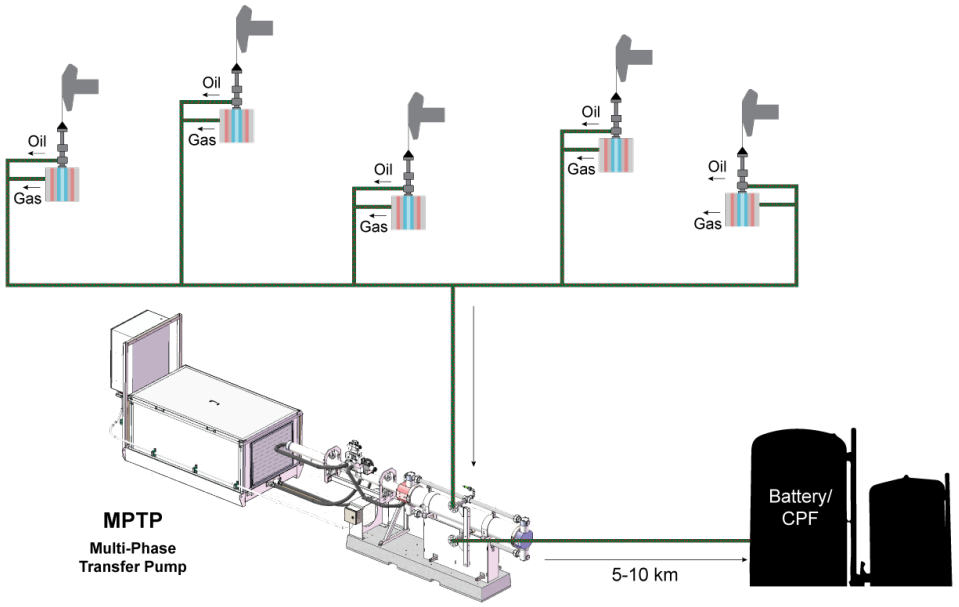
Preferred Applications

- Casing Gas
- Gas conservation e.g. compressing gas from group separator into flowline rather than sending to flare
- Testing well response to casing gas compression
- Low volume vent gas

HCG15 - 613

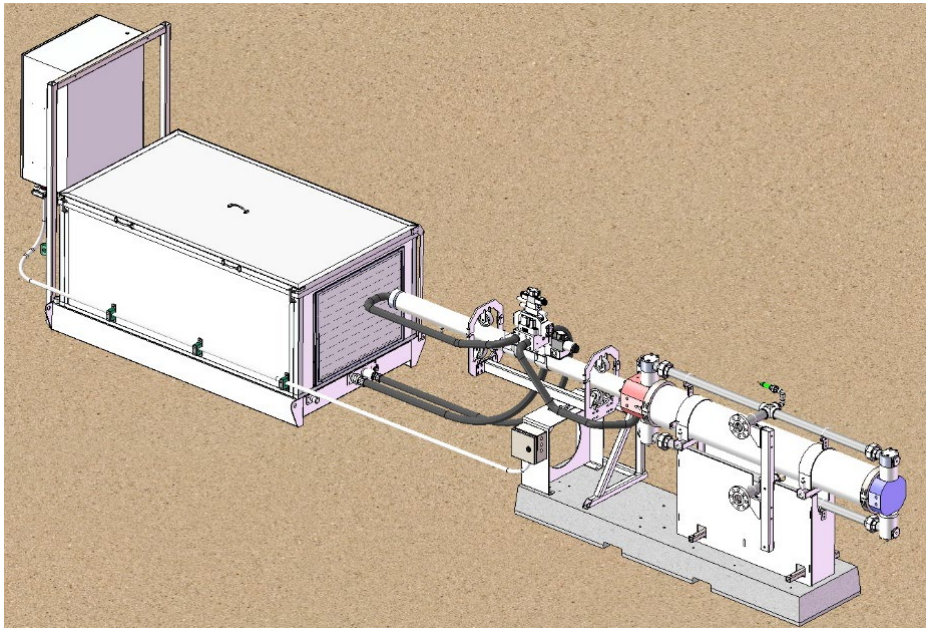
Multiphase Transfer Pump

- Single-stage, double-acting reciprocating multiphase pump
- Similar operating principle to hydraulic compressor with enhancements to handle greater quantities of liquid
- Slow speed and long stroke



Multiphase Transfer Pump

- Single stage
- 50 hp/37.5 kW
- Gas fraction 0 – 100%
- Liquid fraction 0 – 100%
- Suction up to 1200 psi/8273 kPa
- Discharge up to 1500 psi/ 10342 kPa
- Differential pressure up to 350 psi/ 2413 kPa ΔP
- Liquid rates to 16,730 bpd/ 2,660 m^3/d



MPTP50

Multiphase Transfer Pump

Advantages

- Capable of multiphase flow of 0% - 100% liquid fraction
- 100% turndown
- Seals vent internally
- No minimum liquid fraction required
- Very low capital cost
- Very low maintenance cost
- Overhaul in field with no special lifting equipment

Disadvantages

- Hydraulic oil requires periodic replenishment
- Pulsating flow

Multiphase Transfer Pump

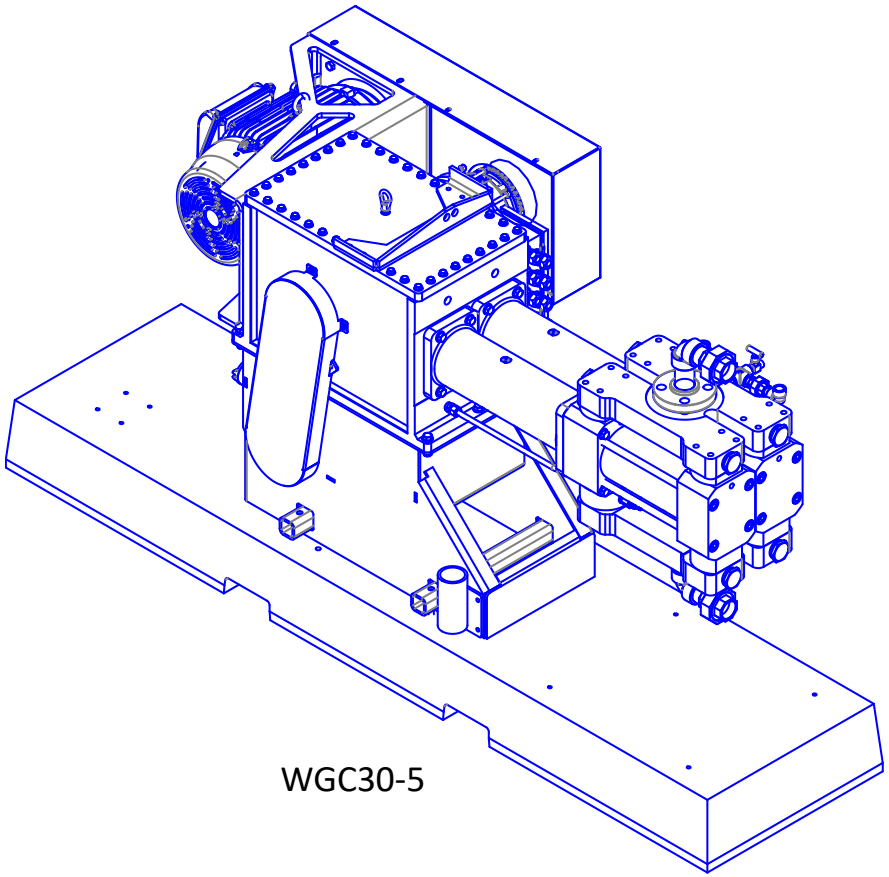
Preferred Applications

- Group header pressure reduction
- Process optimization
- Replacement of aging and maintenance intensive twin screw multiphase pumps
- OPEX reduction

MPTP50

Wet Gas

- Two-cylinder single-stage, double-acting reciprocating compressor
- Direct-driven by electric or hydraulic motor
- Able to process large quantities of liquids through compression element



WGC30-5

Wet Gas

- 15-30 hp/11-23 kW
- Suction 0-1200 psi/0-8300 kPa
- Discharge up to 1200 psi/ 8300 kPa
- Up to 475 psi/3275 kPa ΔP
- Largest model has 1.8x capacity of largest Hydraulic Compressor model

WGC15-4

Wet Gas

Advantages

- Able to process large quantities of liquid through the compression element
- 100% turndown
- Self-regulating control system
- High system efficiency
- Overhaul in field with no special lifting equipment
- Seals vent internally
- Low capital cost

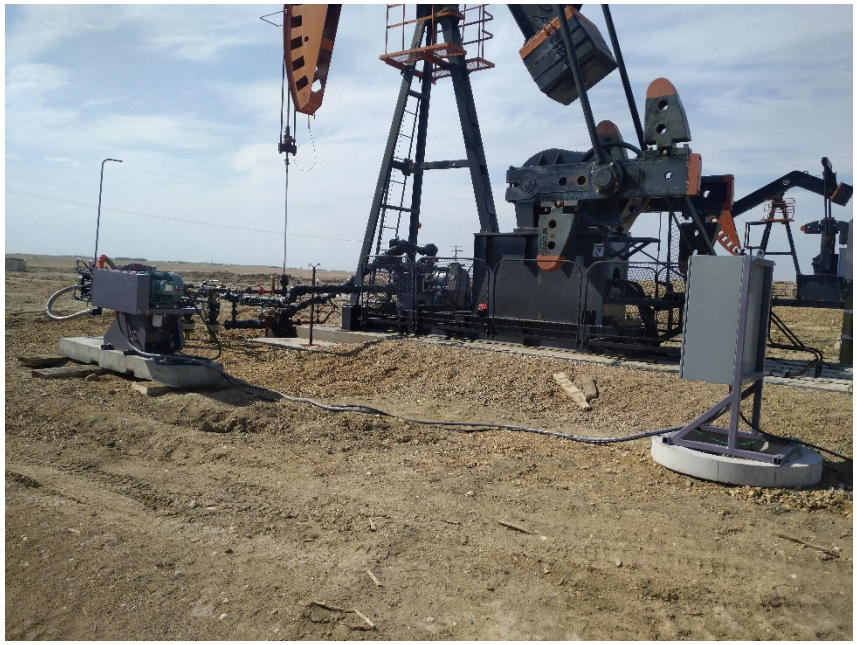
Disadvantages

- Pulsating flow

Wet Gas

Preferred Applications

- Casing gas compression
- Vapour recovery
- Gas conservation e.g. compressing gas from group separator into flowline rather than sending to flare

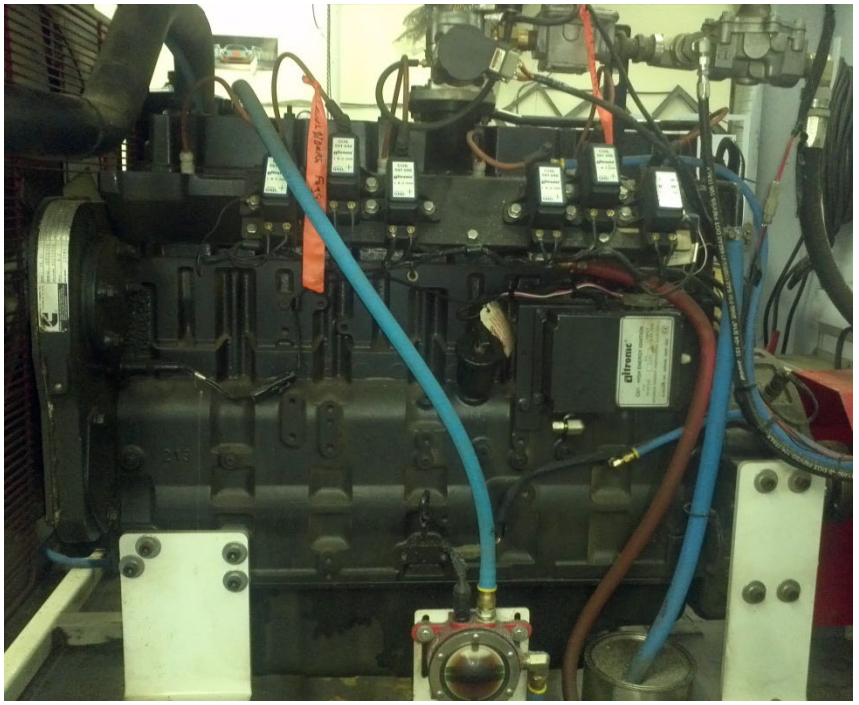


WGC15-4

Drivers – Most Common

Electric Motor

Gas Engine



Drivers – Most Common

Electric Motor

Advantages

- Low maintenance
- Inexpensive

Disadvantages

- Needs electrical power on site
- Speed control (VFD) is expensive

Gas Engine

Advantages

- Runs on process gas, so fuel always available
- Fuel is free or inexpensive

Disadvantages

- Higher initial cost
- Monthly maintenance required
- May struggle with low BTU gas streams

Drivers – Alternative

Diesel Engine

Advantages

- Readily available engines and parts
- No fuel issues – can process any gas stream

Disadvantages

- Higher cost of fuel, including cost of transport

Hydraulic Motor

Advantages

- Low maintenance
- Inexpensive in low power and speed ranges
- Large range of operating speed

Disadvantages

- Requires hydraulic power source

COMPACT COMPRESSION

No Hassle Compression®

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