

MULTIPHASE PRODUCTION SYSTEMS



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For more than fifty years, the Oil and Gas Industry has relied on Twin-Screw Pumps to operate reliably and economically in crude oil applications. The benefits of this positive displacement machine are easily recognized: few moving parts, gas tolerance, operable at typical motor speeds, and hydraulically balanced. In the late 1980s, the industry demanded one more feature from Twin-Screw Pumps: the ability to displace untreated well flow through one piece of equipment. The result...the Leistriz Multiphase Pump.



MULTIPHASE WELLHEAD SYSTEM..... 8

PURPOSE

Wellhead pressure boosting and assisting low pressure producing wells

APPLICATION

- Boost declining well pressure to buck pipeline pressure
- Reduce the amount of gas lift and/or differential pressure on down hole pumps



MULTIPHASE GATHERING SYSTEM..... 10

PURPOSE

Pressure boosting without gas and liquid separation

APPLICATION

- Lower overall gathering system inlet pressure, allowing low producing wells to overcome flow line pressure from high producing wells
- Reduce the amount of gas lift and/or differential pressure on a down hole pump



MULTIPHASE BLOW DOWN UNIT.....12

PURPOSE

Liquid unloading of gas wells

APPLICATION

- Remove and boost liquids when gas wells stop flowing due to liquid loading



MULTIPHASE ANNULUS GAS UNIT.....14

PURPOSE

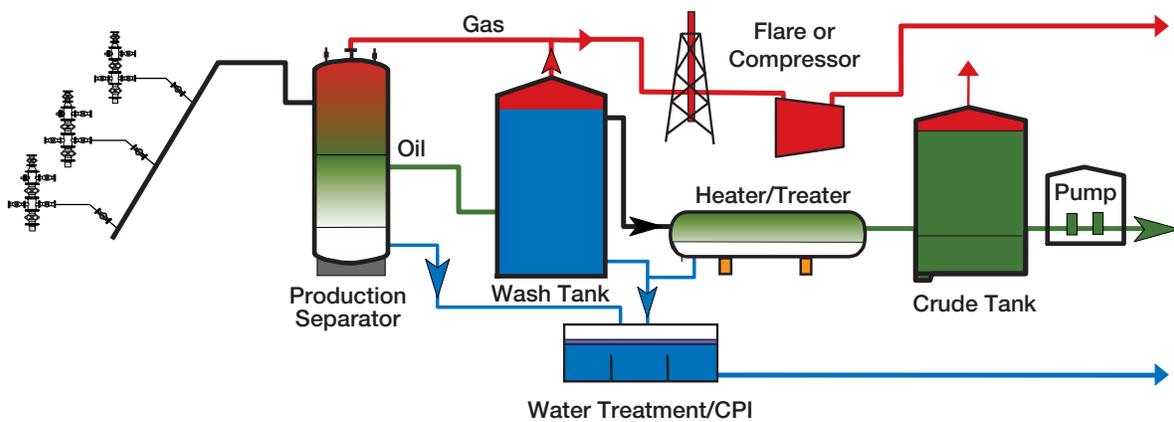
Continuously remove annulus gas for improved inflow to a beam pump

APPLICATION

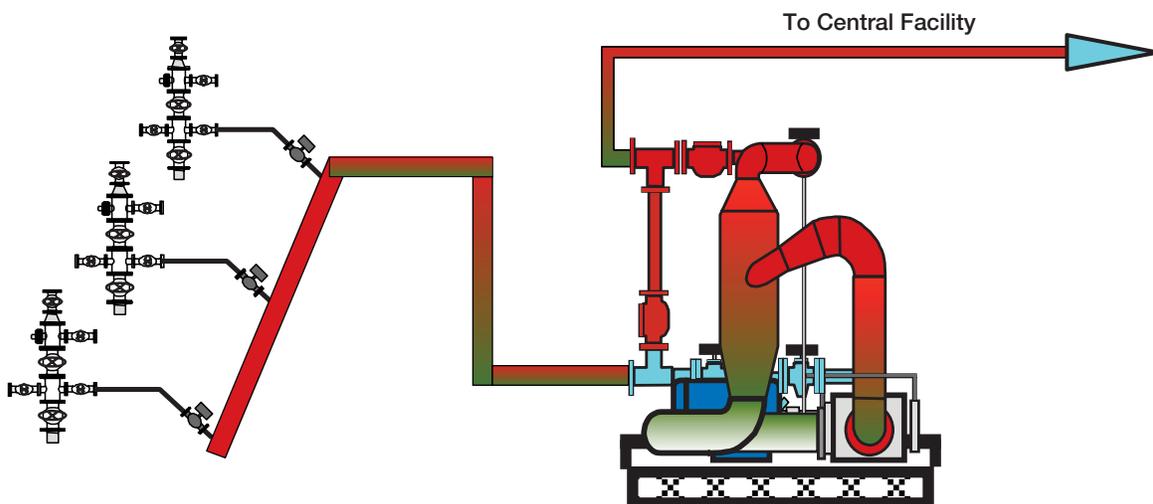
- Increase inflow to a beam pump producing oil with a high GOR

Leistritz Multiphase Pumps are connected upstream of any process equipment. This eliminates the need for onsite separators, heater treaters, wash tanks, crude/water tanks, complicated control systems, separate gas/oil pipelines, multiple pieces of rotating equipment and flaring. The utilization of Multiphase Pumps at the well pad and/or gathering facilities, allows operators to centralize process facilities, reduce the local environmental impact and footprint at the well site, and most importantly – operate safely and reliably.

Conventional Production Systems



Multiphase Production Systems



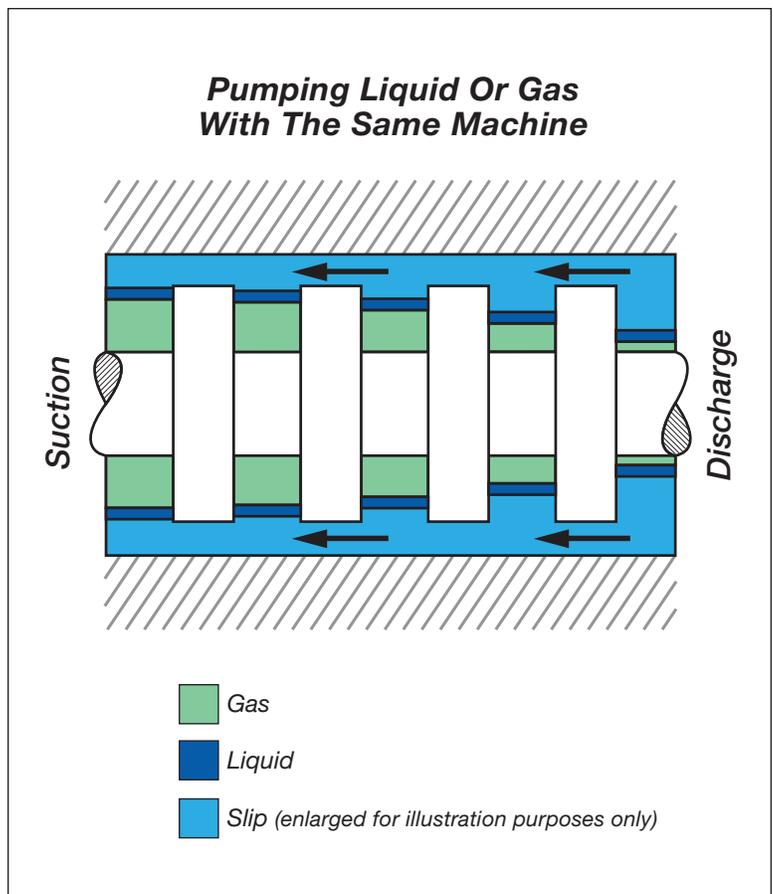
HOW LEISTRITZ MULTIPHASE PUMPS (MPPs) WORK

Two rotors are positioned side by side in the horizontal plane of the MPP liner. There is a clearance between the screws and also between the screws and the liner. When the multiphase flow enters the MPP inlet, it is internally split to opposing ends of the rotor set. As the rotors turn, the multiphase flow is axially displaced through the screw cavities from opposing ends of the screws toward the center and then pushed out through the MPP discharge.

When the multiphase flow enters the first pumping chamber of the MPP, liquids (both water and hydrocarbons) are forced to the screw profile's outer diameter by centrifugal forces. This seals off the pumping chambers, traps the gases and moves them axially through the first few pumping chambers. In the final few pumping chambers, the pipeline back pressure forces liquid to flow or "slip" from the discharge chamber to suction chamber. It is this "slip" liquid that actually performs the compression work. The MPP is not creating pressure. It simply pushes the mixed flow against the pipeline back pressure, as if it were an infinite piston stroke.

When selecting MPPs, the deciding factor for their size is the total liquid and gas volumes at inlet pressure and inlet temperature. This total volume is expressed in terms of total Barrels per Day Equivalent (bpde). The total actual bpde is calculated by converting the gas volume to an equivalent liquid volume and then adding that value to the liquid volume.

The gas volume is often referenced in terms of percent of Gas Volume Fraction or GVF. The GVF is an average value and not a continuous gas/liquid ratio. What is typical for multiphase flow is slugging, which means random intervals of 100% gas, 100% liquid and varying GVFs. Since the MPP relies on liquid to seal the pumping chambers and take away the heat of compression, some liquid from the multiphase flow must be trapped for recirculation back to the MPP suction, thus maintaining prime.



LEISTRITZ LIQUID TRAPPING

The reliable and MPP friendly means of trapping liquid is to knock-out liquid external to, and downstream of, the MPP. By installing a liquid knock-out boot (LKOB) downstream of the MPP, we efficiently knock-out liquids for recirculation and have the flexibility to size the LKOB for an operator's anticipated gas slug interval. LKOBs trap any unwanted solids external to the MPP without constantly re-injecting them back into the MPP.

The LKOB also has the advantage of allowing the addition of a cooler to the recirculation line for applications at very high GVs, such as wet gas compression.

Liquid collected in the LKOB is then re-circulated back to the pump suction through the mechanical seal chamber and/or the pump suction chamber. Since the knock-out liquid is under discharge pressure, orifices or valves are used to control the pressure and flow.



LEISTRITZ MULTIPHASE PUMP DESIGN

The two rotors are supported on each end by roller bearings. These bearings position the rotors within the liner and also maintain the clearances of these rotating elements. The bearings are lubricated by either an oil sump integral with the MPP casing or by forced lubrication for higher differential pressure and/or flow applications.

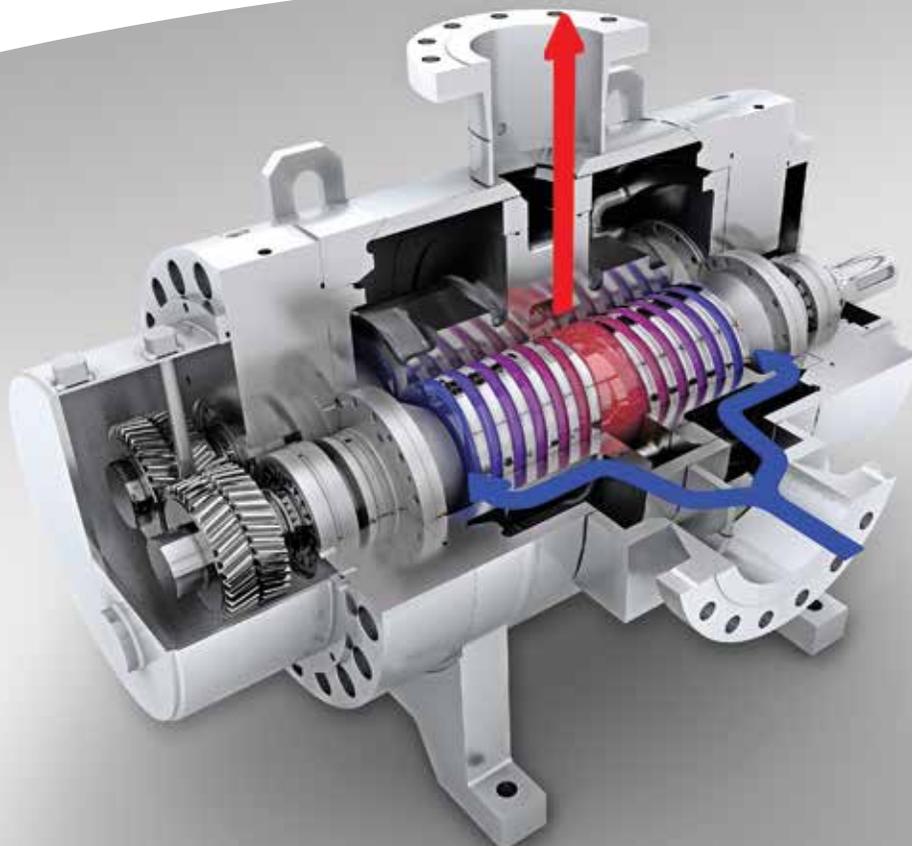
Herringbone timing gears are used to transmit the torque from the drive screw to the driven screw. The timing gears are external to the multiphase flow and are lubricated by an oil sump or forced lubrication.

In order to isolate the bearings and timing gears from the multiphase flow, mechanical seals are installed on each end of the rotor set inboard of the bearings. The mechanical seals are available in a variety of configurations that include: single seal, single seal with throttle bushing, double seal and double seal with throttle bushing. The mechanical seals can be designed to meet the intent of API 682.

The MPP casing is typically constructed of fabricated or cast steel and the replaceable liners are either ductile iron or cast steel. Due to the potential for abrasive elements in the multiphase flow, we also offer the option of

hardening the liner surface. Various other alloys are also available depending on the pumped fluids.

The rotor design is truly our Core Technology. Due to the severity of the application and the extreme importance placed on safe, reliable operation, Leistriz machines all screws out of one solid piece of bar stock. This means the rotor profiles are integral to the shaft, enabling the industry's largest rotor root diameter. A large root diameter maximizes rigidity, thus minimizing deflection and ensuring a non-contacting design. The rigidity of our rotors enables us to locate the discharge chamber mid-span, thus allowing installation of the mechanical seals in the suction chamber. This allows the seal faces to run parallel even in high inlet pressure applications. The single-piece rotors allow operation at higher speeds, significantly improving the MPP's efficiency.



LEISTRITZ MULTIPHASE PUMP SELECTION AND OPERATION

The pump size and performance are determined by the inlet volume at a given inlet temperature and pressure. Since the MPP is a positive displacement pump, varying the MPP speed will proportionately vary the volumetric throughput. By increasing the MPP speed, the inlet (typically wellhead) pressure will decrease and the flow rate will increase. Conversely, lowering the MPP speed will increase the inlet pressure and decrease the flow rate.

Operators determine the optimal MPP inlet pressure to meet their production goals. This inlet pressure then determines the speed of the MPP. Since most MPPs operate with some form of variable speed control, a PLC will constantly monitor the inlet pressure and

then adjust the MPP speed accordingly. This constant monitoring of inlet pressure is required due to the naturally changing wellhead and reservoir pressures.

Most production methods require phase separation, pulsation dampeners, slug catchers and other costly equipment. MPPs do not require any of this additional equipment. MPPs handle the untreated well stream and the pump performance remains constant whether it is displacing 100% gas, 100% liquid or any GVF in between.

The MPP is a positive displacement, constant torque machine that operates independently of downstream back pressure. Therefore the MPP torque requirement does not change with changing well stream phase (GVF).

LEISTRITZ MULTIPHASE PRODUCTION SYSTEMS

Leistritz offers a complete line of standard Multiphase Pumping Systems (MPS) designed to address four specific Oil and Gas Field applications. Each MPS can reliably and economically boost production rates. Capitalizing on Leistritz' MPP technology, our standard MPSs are designed specifically for Wellhead, Gathering, Liquid Blow Down and Liquid Unloading applications. All MPPs are designed in accordance with API 676 3rd

Edition and the full line of standard MPSs are designed in accordance with general industry standards, including: API, ASME, NACE, ASTM, NEMA and AWS. Each system or unit is also customizable to meet an operator's particular set of codes or specifications.

All systems are fully supported by our experienced engineering and service personnel. Our personnel are available for commissioning, training and service work.



MULTIPHASE WELLHEAD SYSTEM

Applications

- *Boost declining well pressure to buck pipeline pressure.*
- *Reduce the amount of gas lift and/or differential pressure on a down hole pump.*



The Leistriz Multiphase Wellhead System (MWS) is a proven and economical method of artificial lift that accelerates production by lowering wellhead pressure and/or boosting discharge pressure to buck pipeline pressure. MWSs handle total flow rates up to 100,000 bpde and differential pressures up to 500 psi. These fully automated systems have a small footprint and eliminate flaring, local separation facilities and water storage, allowing operators to take advantage of more cost effective centralized process facilities.

Scope of Supply

- Leistriz Multiphase Pump
- Seal oil system, API plan 53B (2 per pump)
- Inverter duty electric motor (1800 rpm)
- Spacer coupling and guard
- Structural steel skid with raised rim and common drain (foundation mount)
- Suction piping with strainer and manual isolation valve
- Discharge piping with liquid knock-out boot, check valve, manual isolation valve and full flow relief valve (piped to suction)
- Bypass piping with check valve
- Instrumentation (reference applicable P&ID) and on skid wiring to junction box
- VFD and PLC (shipped loose for mounting and wiring in climate controlled enclosure by others)

Required Utilities

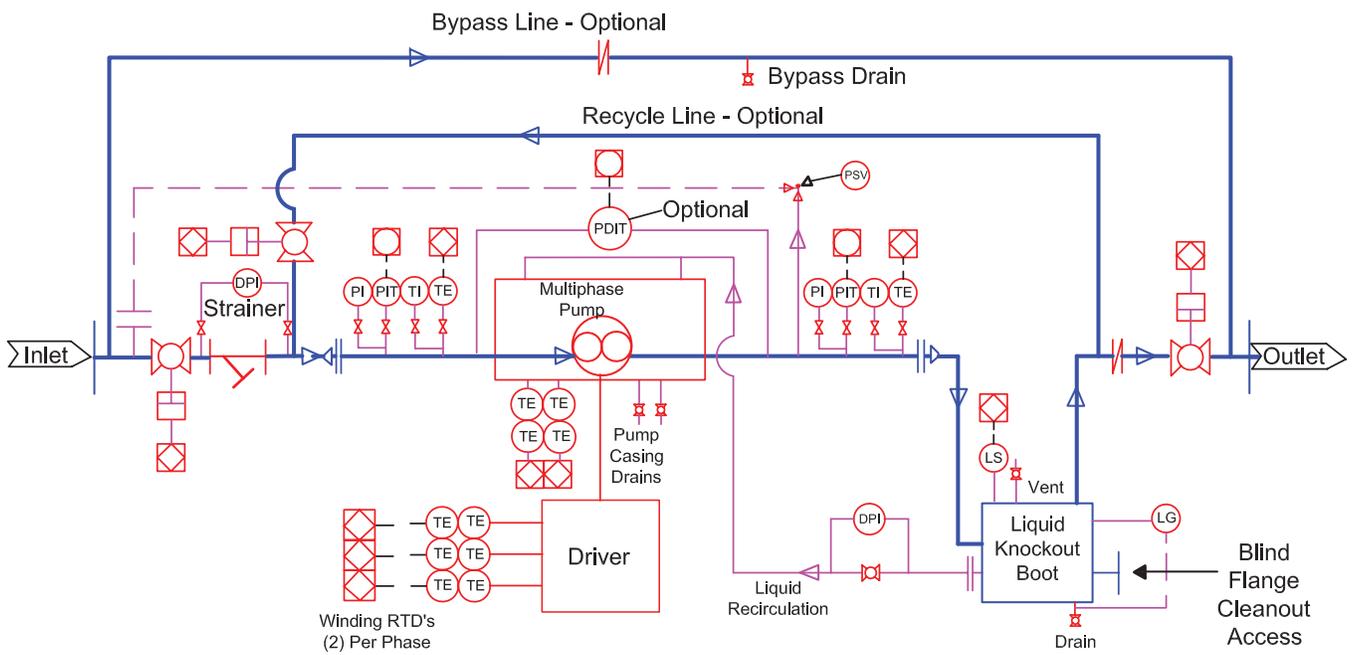
- Initial liquid fill of liquid knock-out boot
- Electricity – motor, seal oil system and instruments
- Initial oil fill of seal oil system

System and Area Classification

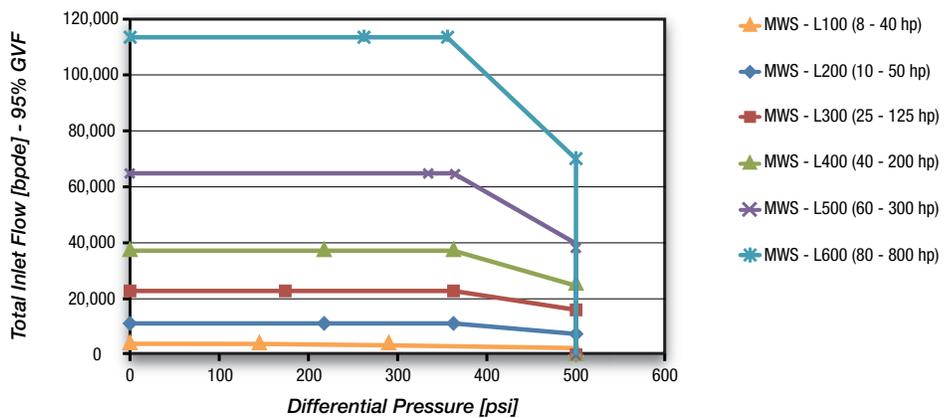
- Class I, Division II

Optional Items

- 3600 rpm Driver
- Up to 2000 psi inlet pressure
- Natural gas engine or diesel engine driver
- Single mechanical seal or single mechanical seal with throttle bushing
- Drag skid mounting (size dependent)
- Seal drain collection tank with monitoring
- Actuated valves
- Cooler
- Offshore classifications



Multiphase Well Head System



MULTIPHASE GATHERING SYSTEM

Applications

- Lower overall gathering system inlet pressure, allowing low producing wells to overcome flow line pressure from high producing wells.
- Reduce the amount of gas lift and/or differential pressure on down hole pumps.



The Leistriz Multiphase Gathering System (MGSs) are expandable versions of the MWS, designed to handle production from multiple wells. Individual MGSs handle total flow rates up to 550,000 bpde and differential pressures up to 1400 psi. These systems are fully automated and can be expanded to operate multiple MGSs in parallel for facilities requiring additional flow capacity.

Scope of Supply

- Leistriz Multiphase Pump
- Seal oil system, API plan 53B (2 per pump) or 54 (size dependent)
- Lube oil system, API 614, chapter 3 (size dependent)
- Inverter duty electric motor (1800 rpm)
- Spacer coupling and guard
- Structural steel skid with raised rim and common drain (foundation mount)
- Suction piping with strainer and manual isolation valve
- Discharge piping with liquid knock-out boot, check valve, manual isolation valve and full flow relief valve (piped to suction)
- Bypass piping with check valve
- Instrumentation (reference applicable P&ID) and on skid wiring to junction box
- Seal drain collection tank with monitoring
- VFD and PLC (shipped loose for mounting and wiring in climate controlled enclosure by others)

Required Utilities

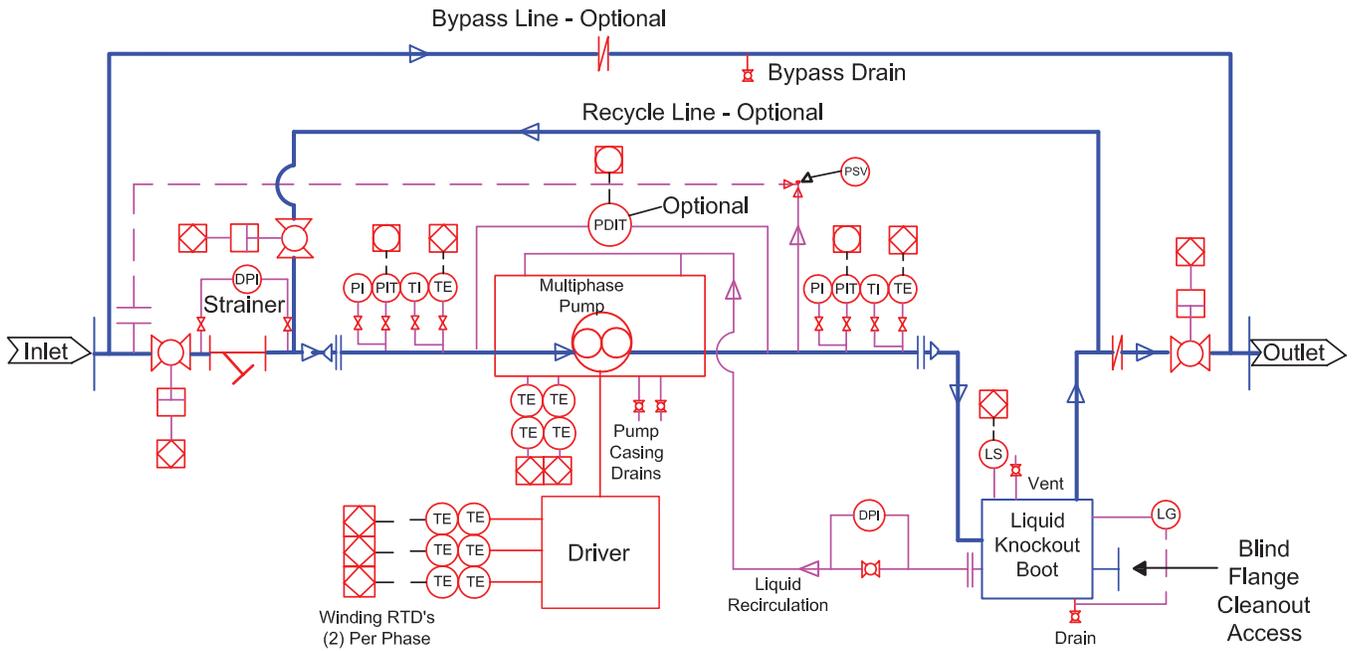
- Initial liquid fill of liquid knock-out boot
- Electricity – motor, seal and lube oil systems and instruments
- Initial oil fill of seal and lube oil systems

System and Area Classification

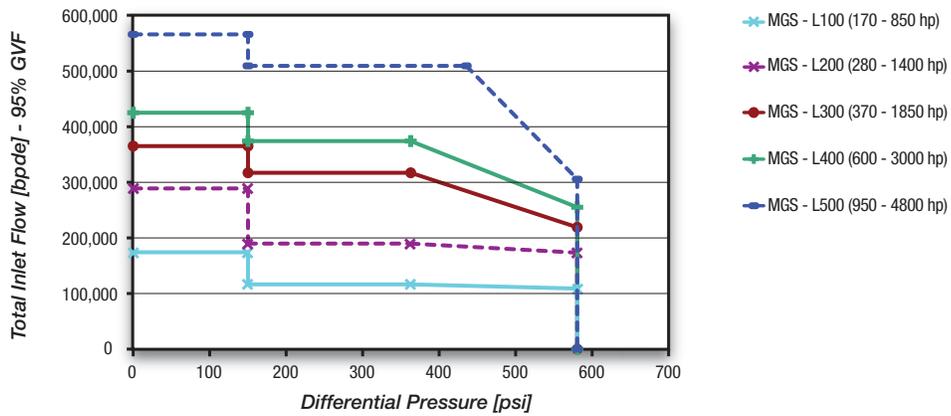
- MGS Low Pressure – 300 lb. system
- MGS High Pressure – 600 lb. system
- Class I, Division II

Optional Items

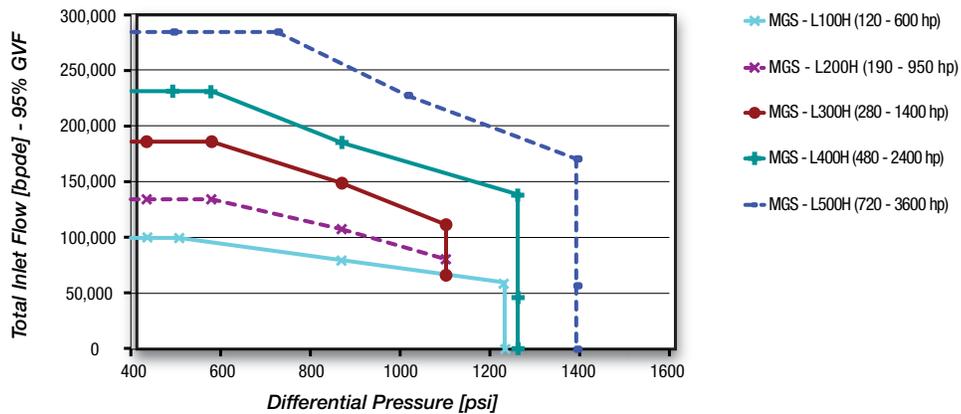
- 3600 rpm Driver
- Up to 2000 psi inlet pressure
- Natural gas engine or diesel engine driver
- Single mechanical seal or single mechanical seal with throttle bushing
- API baseplate
- Actuated valves
- Cooler
- Offshore classifications



MGS - Low Pressure



MGS - High Pressure



MULTIPHASE BLOW DOWN UNIT

Applications

- **Remove and boost liquids when gas wells stop flowing due to liquid loading.**

Typical gas wells produce not only natural gas but also liquids such as water and hydrocarbons like propane and butane. Except in wells where the gas is dominantly dry, NGLs can build up down hole, reducing the gas flow to an extent where the well is shut in and cannot buck the line pressure of the export flow line.

The conventional method for alleviating this down hole liquid restriction is to disconnect the well from the pipeline and then free flow the well into a portable tank until the gas begins to free flow again. The pressure in the tanks is usually lowered by venting directly to the atmosphere releasing VOCs and creating environmental permitting issues. The liquids trapped in the tank then require removal, typically by truck. This increases heavy traffic, often in sensitive areas, and significantly impacts production costs.

This conventional blow down method, increasingly under attack in many states, is costly to execute and leads to potentially dangerous work environments. Other possible solutions, such as soap sticks, plunger lifts, pump jacks and ESPs are not always effective and expensive to install and maintain.

Scope of Supply

- Leistritz Multiphase Pump
- Natural gas engine with battery, radiator, muffler, PTO and fuel conditioning system
- Gear box
- Couplings and guards
- Trailer mounted structural steel skid with raised rim and common drain
- Cooler
- Suction piping with strainer and actuated ESD valve
- Discharge piping with liquid knock-out boot (including demister), check valve, manual isolation valve and full flow relief valve (piped to suction)
- Bypass piping with check valve
- Instrumentation (reference applicable P&ID) and on skid wiring to PLC
- Seal drain collection tank with monitoring

The simple solution is a Leistritz Multiphase Blow Down Unit (MBDU). This portable, self-contained unit simultaneously evacuates both the liquids and gases trapped within the tube and boosts the well pressure allowing the gas and trapped liquids to flow into the existing pipeline. This eliminates the need to vent or flare gas, transport hydrocarbons over public roadways and most importantly allows the operator to capture all the valuable gas and NGLs in their existing pipeline network.

A typical blow down cycle starts by connecting the MBDU in by-pass mode to the gas well export line. The MBDU starts pumping against full discharge (or pipeline) pressure with well shut-in pressure at the inlet. After a short period of time the MBDU builds differential pressure by drawing down the wellhead pressure. The gas starts flowing through the MBDU with increasing velocity, dragging along increasing amounts of liquid, eventually restoring the well to the desired flow and pressure conditions. Once the original conditions are restored, the MBDU is disconnected from the well and transported to another well site to repeat the same procedure.

Required Utilities

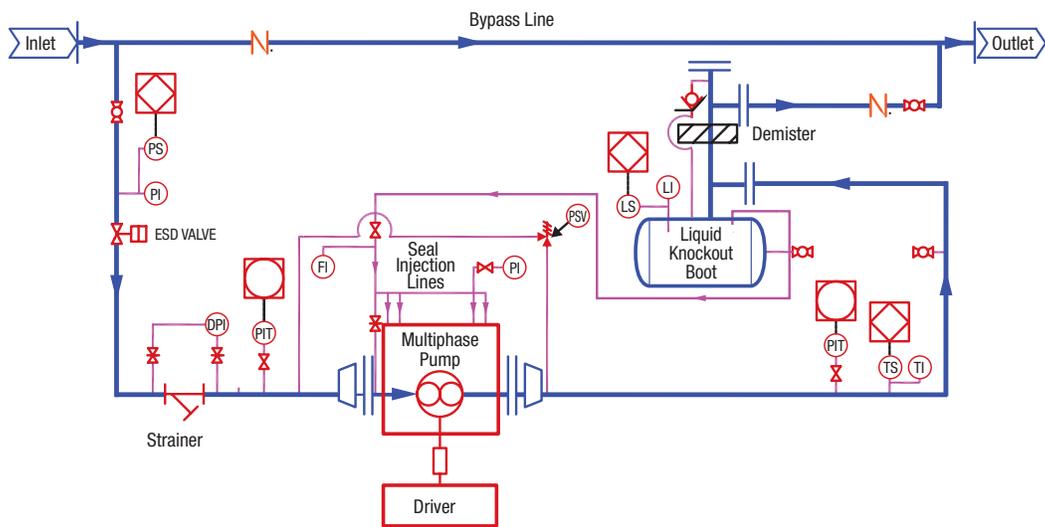
- Initial liquid fill of liquid knock-out boot
- Fuel gas from sales gas line

System and Area Classification

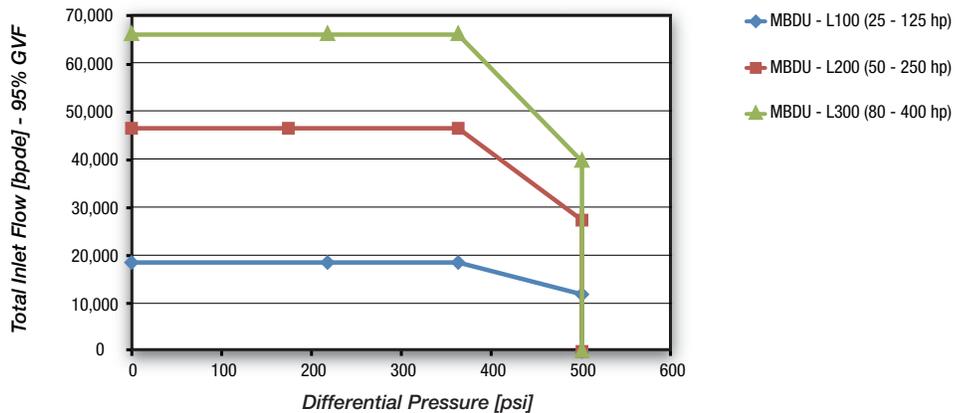
- 300 lb. System
- Class I, Division II

Optional Items

- Inlet pressure control valve
- Electric motor or diesel engine driver
- Double mechanical seal with throttle bushing and API plan 53B seal oil system
- Drag skid
- Actuated valves



Multiphase Blow Down Unit



MULTIPHASE ANNULUS GAS UNIT

Applications

■ *Increase inflow to a beam pump producing oil with a high GOR.*

Oil wells produced by beam pumps tend to experience frequent or extended outages due to associated gas. If too much gas accumulates down-hole, the beam pump will simply shut down until enough gas passes up the annulus into the flow line. A typical method of assisting the gas through the annulus is to install a compressor. However, liquids also tend to come up with the gas, which can overwhelm the compressor, tripping their shutoff and causing the beam pump to shut in production. The beam pump mounted compressors are an alternative solution to this problem, but their limited ability to draw down the wellhead pressure reduces their long-term effectiveness.

A versatile and effective solution to boosting the associated gas is a Multiphase Annulus Gas Unit (MAGU). These self contained units efficiently boost gas and liquids coming up the annulus and boost the multiphase flow directly into the flow line back to the satellite or battery. By lowering the bottom hole pressure, substantially more liquids flow from the formation into the beam pump, increasing overall production. Since the MAGUs handle every

phase from 100% gas to 100% liquid, they cannot be overwhelmed by a liquid slug, and operating the unit with an optional speed control allows greater production flexibility over the life of the well.

Each unit has two inlet connections. The first inlet connects to the production line coming off the beam pump. The total flow from the beam pump passes through a liquid knock-out boot, trapping a small amount of liquids for priming the Multiphase Pump, while the remainder of the flow continues on to the battery or gathering facility.

The second inlet connects to the annulus gas line and flows to the Multiphase Pump suction. A slip stream of liquid from the liquid knock-out boot ensures the MPP remains primed and therefore able to pump 100% gas from the annulus line. The MPP discharge line connects to the beam pump discharge line, down stream of the liquid knock-out boot.

MAGUs are typically mounted on a drag skid and can be moved easily from one well to another or left in place to support one well.

Scope of Supply

- Leistritz Multiphase Pump
- Electric motor (3600 rpm)
- Spacer coupling and guard
- Structural steel drag skid with raised rim and common drain
- Suction piping with strainer and check valve
- Discharge piping with liquid knock-out boot (including demister) and full flow relief valve (piped to suction)
- Instrumentation (reference applicable P&ID)

Required Utilities

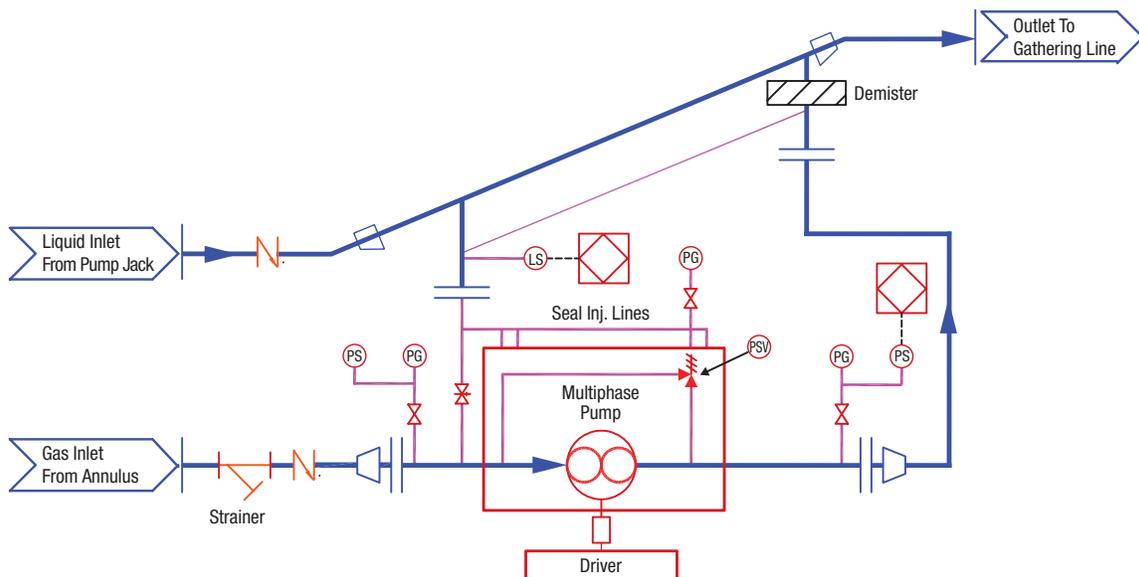
- Initial liquid fill of liquid knock-out boot
- Electricity – motor
- Customer supplied motor starter

System and Area Classification

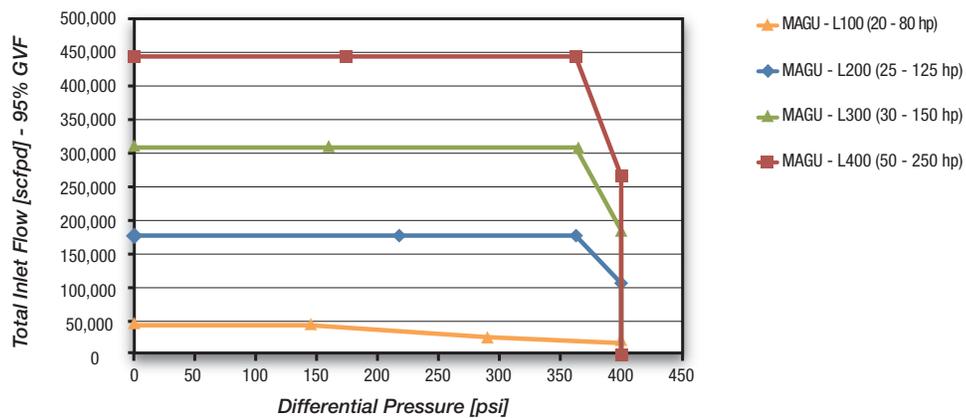
- 300 lb. System
- Class I, Division II

Optional Items

- 150 lbs. Class System
- Cooler
- Trailer Mount
- VFD (shipped loose for mounting and wiring in climate controlled enclosure by others)



Multiphase Annulus Gas Unit



For more information about our Multiphase Production Systems, or for complete descriptions of other Leistritz screw pumps, call us directly, or visit the Leistritz web site at www.leistritzcorp.com/pumps.

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WELLHEAD SYSTEM



Increase production from low producing or aging wells.

GATHERING SYSTEM



Minimize capital and operating expenses by boosting wells without separation.

BLOW DOWN UNIT



Unload liquid from gas wells with minimal environmental impact.

ANNULUS GAS UNIT



Maximize beam pump uptime by continuously removing annulus gas.