Packer-Type Gas Separator with Seating Nipple

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Gravity Gas Separation from Liquid

Gas/Liquid Separation is based on the principle that gas is lighter than liquid and tends to rise.

A LIQUID COLUMN HAVING AN AREA OF 1 SQUARE INCH TRAVELLING AT A VELOCITY OF 6 INCHES PER SECOND IS A RATE OF APPROXIMATELY 50 BPD.

GAS BUBBLES FLOW UPWARD IN OIL OR WATER AT A RATE OF APPROXIMATELY 6 INCHES PER SECOND. THUS, GAS BUBBLES WILL BE RELEASED FROM LIQUID IF THE DOWNWARD LIQUID VELOCITY IS LESS THAN 6 INCHES PER SECOND.
Natural Gas Separator

- The most efficient downhole gas separators locate the pump intake below the lowest gas entry point.

- Gas is not pulled down to the pump perforations unless the liquid velocity is greater than 6 inches per second.

- Maximum capacity is obtained using casing annulus.
Sorry “Poor Boy” Gas Separator

Limited Flow Area and Small 3/8 inch holes in perforated sub limit gas exit flow and liquid entry thus reducing separation efficiency.

Tubing Collars prevent perforated sub from laying against casing wall where liquid accumulates.

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Collar Size Separator Increases Liquid Capacity

A good separator must strike a balance between annular flow area, separator flow area, dip tube diameter and pressure drop.

- Outer barrel OD same as collar OD.
- Thin wall outer barrel and dip tube.
- Short flow conduits.
- Large inlet ports.

Fig. 5 Collar-Size Gas Separator in Casing
Packer Gas Separator

- Uses gravity separation like the “Poor Boy” except much more separation area and capacity.

- Higher cost and higher risk of mechanical and sand problems.

- Page Oil Tools 1957
A concentric packer type gas separator offers additional liquid and gas capacities.

Note that the seating nipple is located immediately above the packer in this separator system.

Page Oil Tools 1957
Gas Separator Capacity

• A good Gas Separator will separate liquid from gas in the casing annulus and cause the liquid to enter the pump if sufficient liquid exists in the casing annulus.

• If a well has a high fluid level and the pump is not full, the separator is not operating efficiently.

• The pump is not at fault when gas is present in the pump and liquid exists in the casing annulus. Do not blame the pump. It is a separator problem and cannot be fixed by pump design.
Echometer Test Equipment

Allows the operator to measure and analyze pressures, flow rates, liquid level depths, plunger loads and movement, casing annulus gas flow rate and other important performance factors.

Wireless Equipment
Fluid Level Test and Analysis

Cobra Oil and Gas

Packer Type Separator

Production
- Oil: 96 BBL/D
- Water: 73 BBL/D
- Gas: 378.0 Mcf/D

Casing Pressure Buildup
- 6.9 psi
- 100 min

Well State:
- Annular Gas Flow: 511 Mcf/D
- % Liquid: 19

Acoustic Velocity: 1150 ft/s

Total Gaseous Liquid Column HT (TVD): 6981 ft
Equivalent Gas Free Liquid HT (TVD): 1306 ft

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Surface Dynagraphics and Pump Card
Maximum plunger velocity is 80 inches per second and the maximum displacement rate is 1258 BPD (for a 1 ½ inch plunger).

A 2 3/8 inch Mechanical Seating Assembly has a 0.75 inch hole for liquid and gas flow. Thus the liquid must flow through the seating nipple at a rate of 320 inches per second to fill the pump chamber as the plunger is rising.
13 Wells with Packer Type Separators

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17 Variables were Studied
% liquid in Gaseous Liquid Column Vs. % Pump Fillage

Packer Type Separators

Gas Separator Ineffective

Gas Separator Effective

Pump Card Volumetric Fillage (%)

Well State:

Producing

% Liquid
19

Annular Gas Flow 511 Mcf/D

Pump Intake Pressure 521.4 psi (g)
PBHP 1178.2 psi (g)
Reservoir Pressure (SB psi (g)

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Packer Type Separators
Other Pump Fillage Factors

- Variable Diameter Pump Barrel
- Hole/Holes in Pump Barrel
- High Clearance Plunger

Lynn Rowlan Presentation

These conditions will fill the pump chamber but generally lower the total production rate.
Downhole Gas Separator with Seating Nipple

- A new downhole gas separator for high capacity wells is offered that includes a seating nipple.
- The separator is used with a packer or a flow diverter assembly or a tail pipe assembly.
- The downhole gas/liquid separation occurs in the casing annulus between the casing and the outside wall of the separator.
- The pump inlet is very close to the liquid in the casing annulus which results in higher pump fillage.
- The tubing anchor is positioned below instead of above the separator which results in higher pump fillage.
Fluids from the formation flow upward to the gas separator and then flow through a concentric annulus to an outlet at the top of the separator which discharges on one side into the casing annulus.

The gas rises and the liquid falls in the casing annulus.

The pump inlet is located at the bottom of the gas separator causing the pressure drop from the liquid at the bottom of the separator to the pump inlet to be negligible.

Diverter Cups or a packer or tail pipe with packer is located below the Separator to force formation fluids into the separator.
Gas Separator and Seating Nipple

- Top Collar
- Inner and Outer barrels
- Larger Outer barrel over seating nipple
- Seating Nipple, conventional or mechanical
- Two Large Holes for liquid flow into pump inlet
- Lower Collar and mating assembly
Upper Assembly

The discharge port for the formation fluids is on one side of the upper portion of the separator which offers better gas/liquid separation.
Relatively large ports exist for the formation fluids and the liquid
Separator Offers Increased Pump Fillage

- The new high-capacity gas separator has the seating nipple installed within the separator so that a large path of only a few inches exists between the liquid in the casing annulus and the pump inlet.
- The separator is strong. The diverter cups (or packer) are mounted securely to the bottom of the separator. The tubing anchor is mounted securely to the bottom of the diverter cups or packer.
- The diverter cups are strong and the elastomer is actually locked into rings on the insert.
- Field tests of separator performance indicate better performance is obtained from downhole separators if the tubing anchor is located below the separator instead of above the separator.
- The quieting volume size is maximized and the liquid flow paths have minimum pressure drop which result in higher pump fillage.
Packer-Type Separator Configurations

• All of the formation fluid must be directed into the bottom of the separator to pass through the separator and be discharged out of the top of the separator. Then the discharged liquid in the casing annulus falls to the pump inlet and the gas flows upward.

• The flow can be directed through the separator using a:
  – Packer
  – Diverter Cups
  – Tail Pipe with packer

• All installations must have one of the diverter devices to force the formation fluids upward through the separator and out of the top of the separator.
Diverter Cup Assembly

1. A diverter cup assembly has the advantage of being more tolerant of sand and debris problems than a packer. They are very flexible, but they require special care.

2. The flexible diverter cups are mounted on a heavy wall 2.5 inch OD stainless steel tube with male connections on each end. The tube is 30 inches long and 8 cups are installed on the tube. The cups are 1 inch thick and move freely on the tube. The tube moves freely within the diverter cups as the cups are being run into the well. Thus, when going in the hole, the cups are flexed upward, and when a joint of tubing is added to the tubing string, the cups are flexed upward and downward if the cups are not allowed to freely move on the tube. This free movement of cups on the tube prevents excessive flexing of the cups and results in longer cup life.

3. The cup elastomer is bonded to an inner metal insert that slides on the 2.5 inch OD tube. The insert has metal lock rings that cause the elastomer to lock onto the metal rings.

4. When running in the well, a tubing anchor is below the diverter cups which insures that large deposits or obstructions do not exist in the casing annulus which will damage the cups. Water is run into the casing annulus continuously while the separator is being run into the well to lubricate and cool the diverter cups.

A packer can be used if desired. The diverter cups are offered as an option.
Diverter Cup Assembly

- Upper Male connection
- 6 Diverter Cups
- Cups are loose fit to freely slide on mandrel
- Lower Male Connection
Running Sequence

• The tubing anchor is run into the well first followed by the packer or diverter cups followed by the separator. Then the tubing is installed.

• Important: the separator contains the pump seating nipple so another seating nipple above the separator should not be installed.
The tail pipe with packer configuration is very effective and will increase production in a well when the pump is set a considerable distance above the formation. The tail pipe reduces the pressure required to push the formation fluids to the pump so a lower PBHP exists.
Tail Pipe  1000 PSI  PIP

Assume 3000 PSI SBHP
Tail pipe increases production 27%
Tail Pipe  500 PSI PIP

Assume 2000 psi SBHP
Tail pipe will double production
Tail Pipe 100 PSI PIP

Assume SBHP is 1000 PSI
Tail Pipe will more than double production
Tail Pipe View 100 PSI PIP

Liquid Flow 250 Bbl/day, 100% oil - Gas flow 300 MSCF/day

PIP = 100 psi

- Tubing head pressure = 87 psi
- Tubing pressure
- Annulus pressure
- PIP = 100 psi
- PDP = 3200 psi
- Pressure rise through pump
- Top of Packer Pressure = 1500 psi

- Separator 10 ft long
- Seating Nipple in separator
- Tail Pipe ID size: 2.441
- Tail Pipe Pressure 2.441 ID

- Casing head pressure = 150 psi

- Packer

- Liquid

- Gas

- 8000 ft

- 11,500 ft

Sept. 25 - 28, 2012
2012 Sucker Rod Pumping Workshop
Final Slide

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