Oil and Gas Well Completions

Types of Completion

Completion Design Factors

Principal completion design factor include:

- Casing protection
  - e.g., protection against erosion, corrosion
- Tubing string removal
  - e.g., for replacement or workover
- Safety or contingency
  - e.g., requirements for safety valves and well kill
- Production control
  - e.g., components providing flexibility and control of production (nipples, profiles and sliding sleeves

Basic Production Configurations

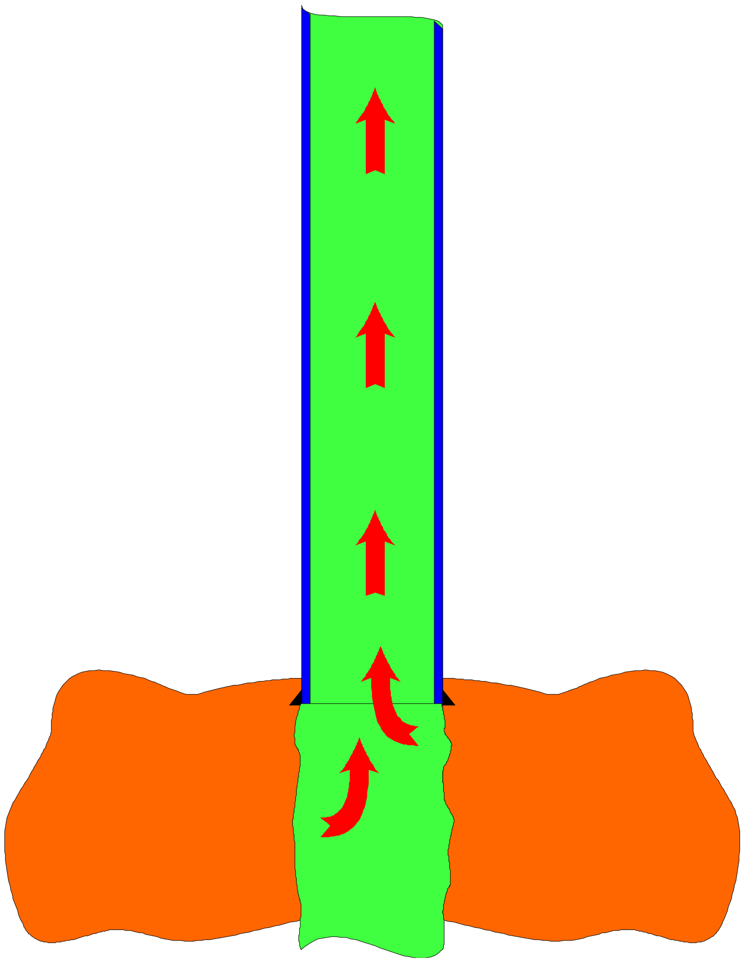
Majority of completions are based on the following completion configurations

- Reservoir interface
  - Openhole
  - Casing production
  - Liner production
  - Gravel pack wellbore
- Production conduit
  - Suspended tubing
  - Basic packer
  - Packer and tailpipe
  - Packer with additional safety and production devices

Open Hole Production

Key points

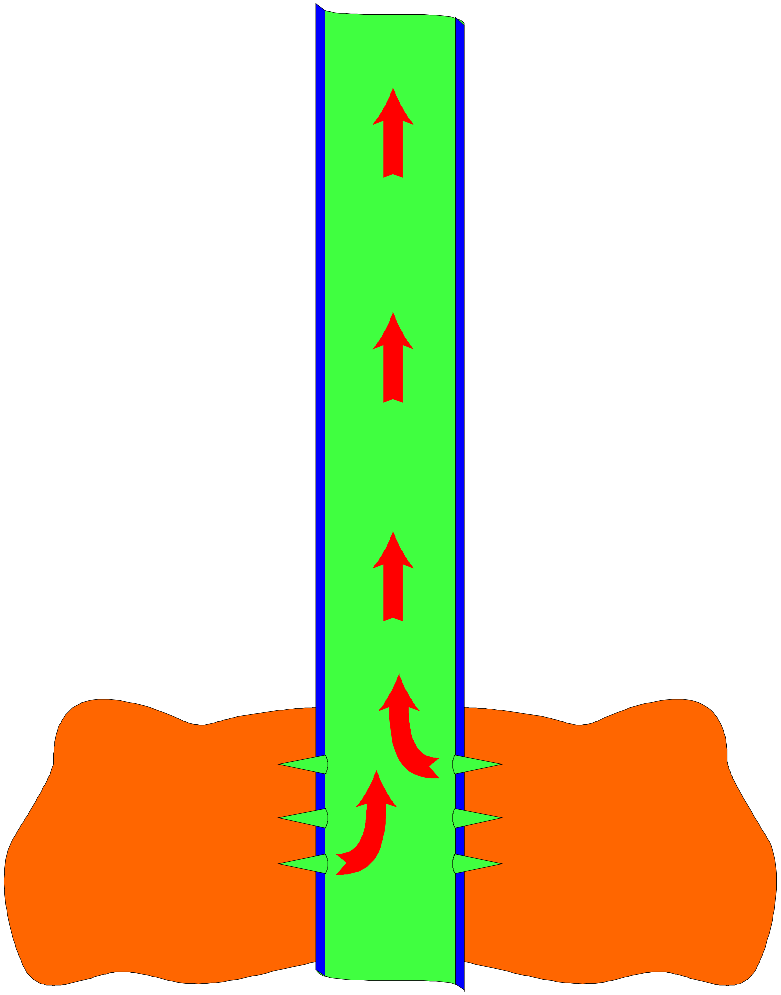
- No downhole flow control or isolation
- Producing formation is unsupported
- Casing provides isolation between shallower formations



Casing Production

Key points

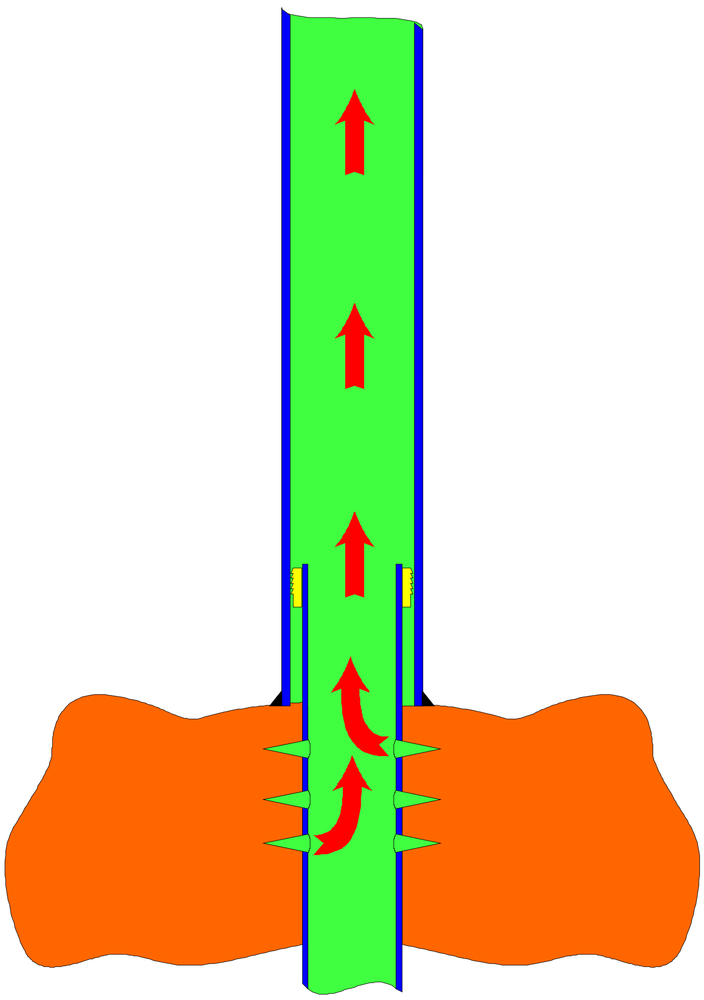
- No downhole flow control or isolation
- Casing provides isolation between shallower formations with potential for remedial work to isolate sections of perforated interval



Liner Production

Key points

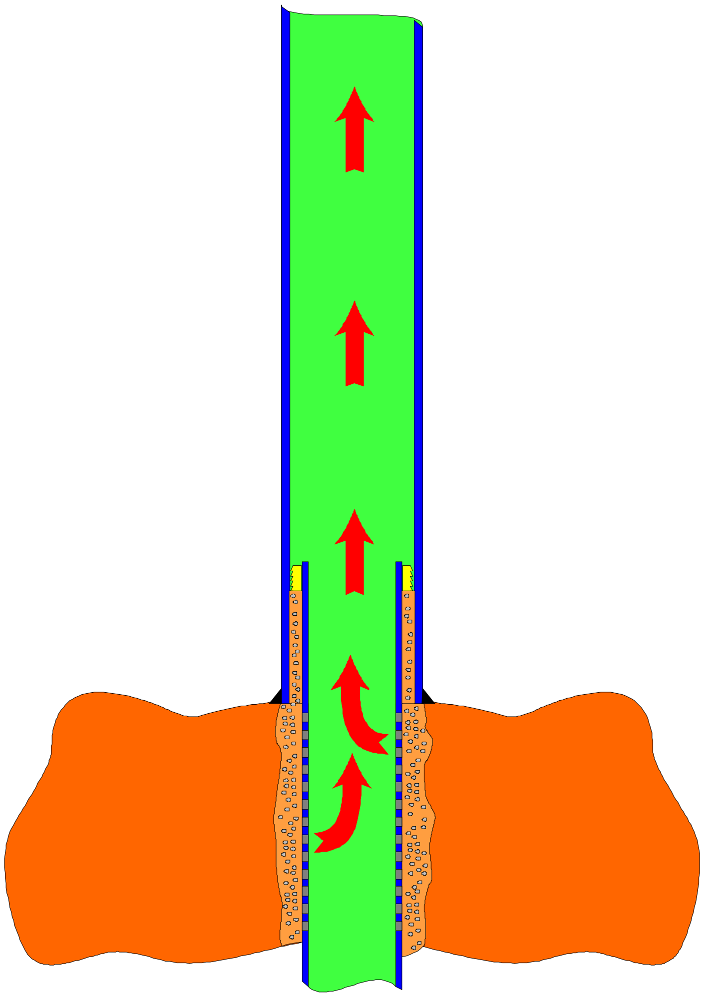
- Similar to casing production but with smaller (and shorter) tubulars set through the reservoir



Gravel Pack Wellbore

Key points

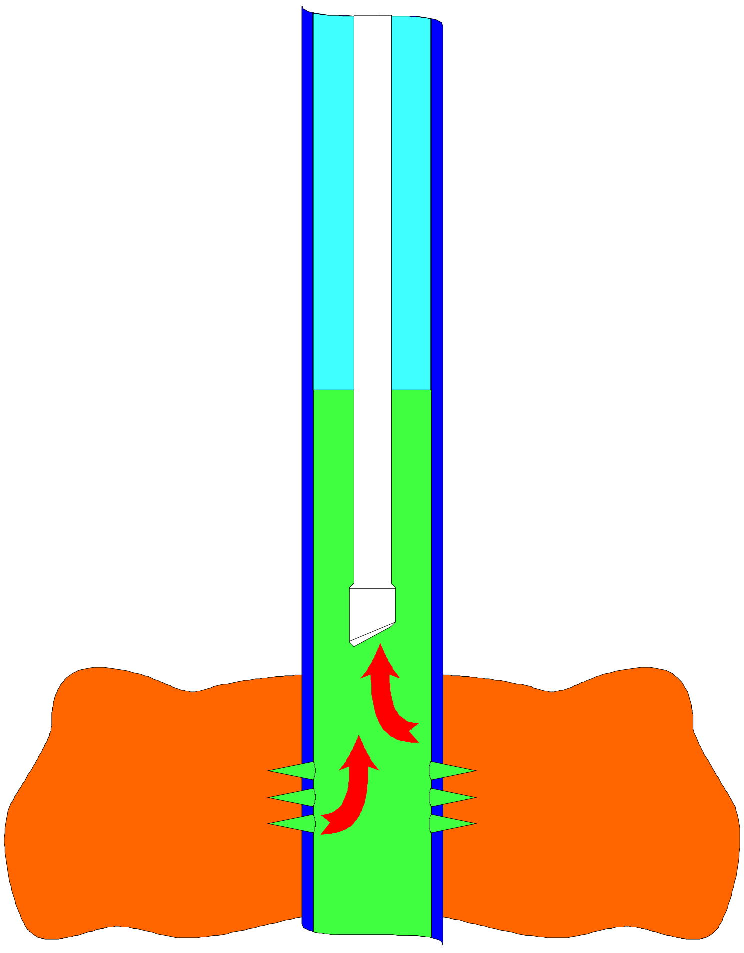
- Special application - requirement determined by formation type
- May require special operation (underreaming) during well construction phase



Simple Tubing Completion

Key features

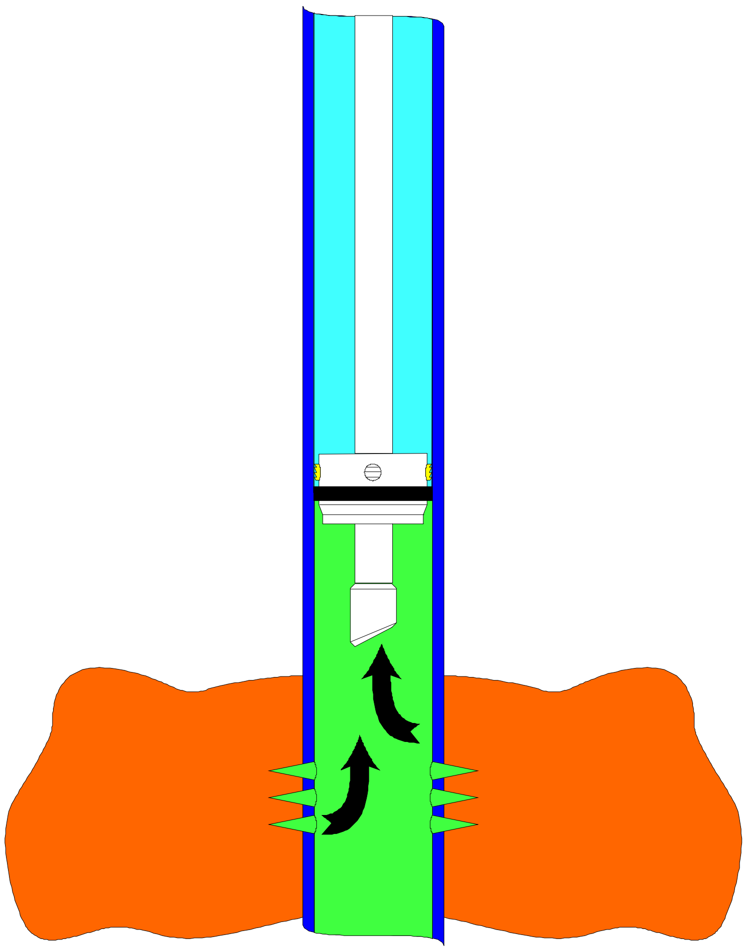
- Circulation capability (well kill or kick-off)
- Improves hydraulic performance
- Limited protection for casing



Basic Packer Completion

Key features

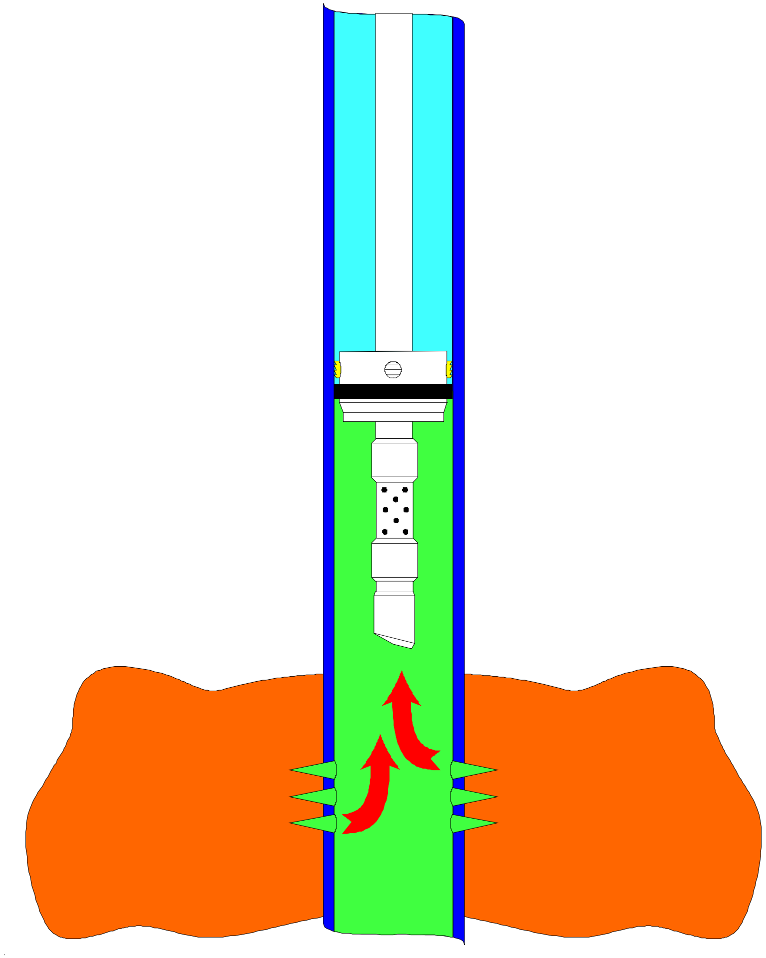
- Circulation capability (determined by design and setting of packer)
- Casing string protected from fluid and pressure effects



Packer with Tailpipe

Key features

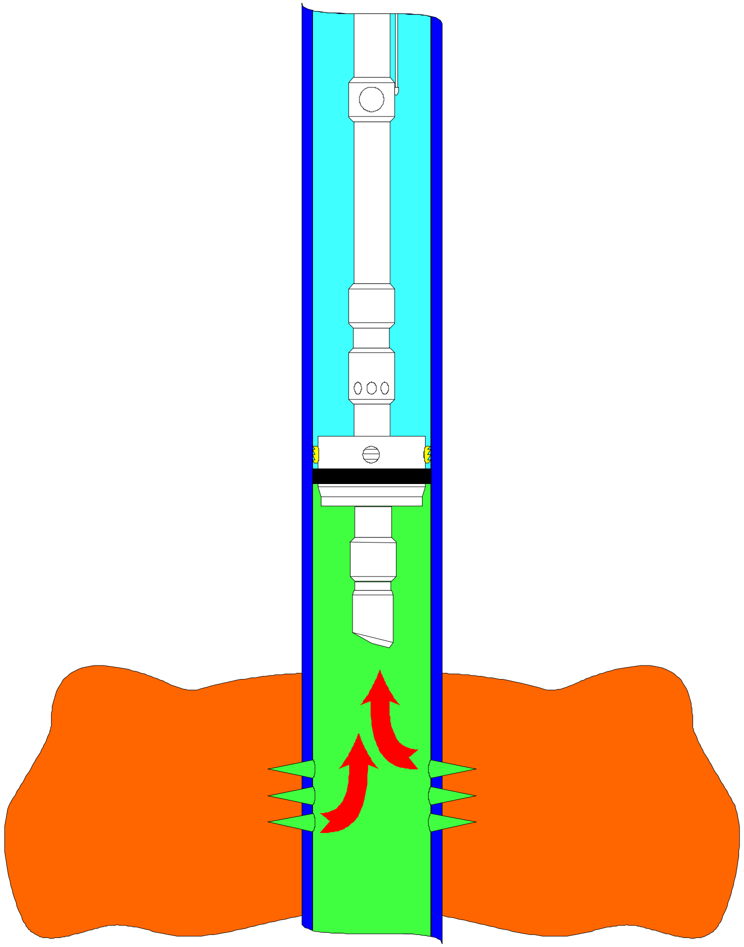
- Additional flexibility for downhole production (flow)control, e.g., plugs
- Facility for downhole instruments (gauges)



Enhanced Packer Installation

Key features

- Improved flexibility for downhole production control, e.g., plugs above or below packer
- Circulation capability independent of packer
- Safety facility (SSSV)



Completion Examples

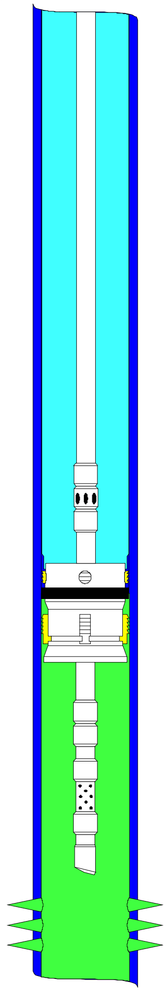
The following completion examples are extracted from design files for:

- Single zone completions
- Multiple zone completions
- Liner completions
- Special completions
  - Sand control
  - Inhibitor injection
  - Waterflood
  - Thermal
  - Remedial (scab liner)

Single Zone – Retrievable Packer

Key Features

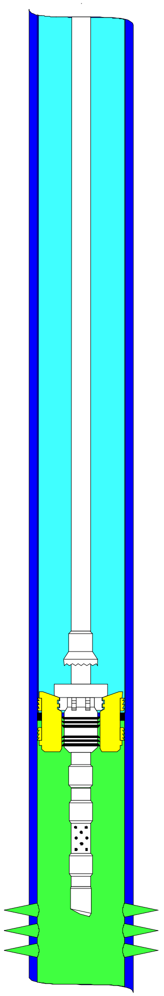
- Tail-pipe facility for pressure and temperature gauges
- Fully retrievable completion
- Packer can be set with well flanged up
- Thru-tubing perforation possible where size permits



Single Zone – Seal-Bore Packer

Key Features

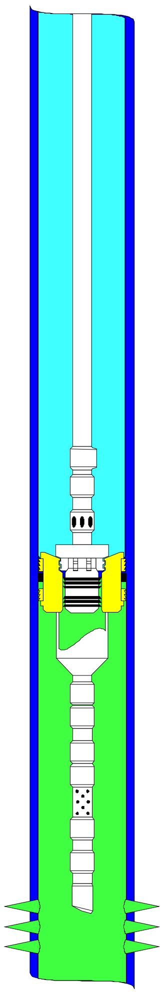
- Seal-bore packer set on electric-line or tubing
- On-off connector and tubing anchor allows tubing to be retrieved
- Tailpipe plugged and left in wellbore or retrieved with production tubing



Single Zone – Packer and Tailpipe

Key Features

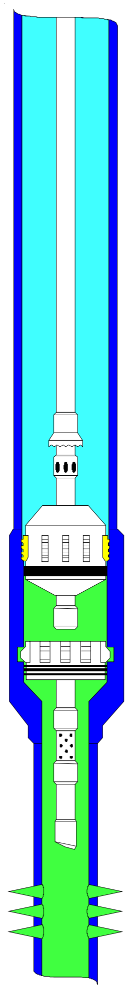
- Tailpipe plugged and left in wellbore when production tubing is retrieved
- Permits safe thru-tubing perforating
- Block and kill system facilitates the killing of high-pressure, high-flowrate wells



Single Zone – Casing Seal Receptacle

Key Features

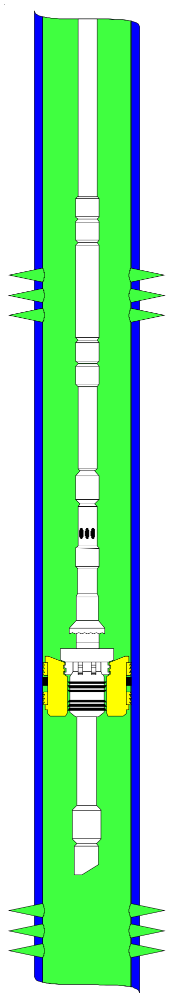
- Expansion joint allows for tubing movement
- Tailpipe retrievable (separately)
- Protective sleeve run in CSR during primary and remedial cementing



Multiple Zones – 2 Zones 1 Packer

Key Features

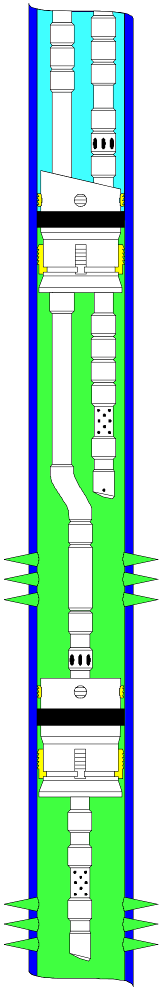
- Separate or commingled production through single tubing string
- Blast joint protection across upper interval
- On-off connector and tubing anchor permits tubing retrieval with lower interval isolated



Multiple Zones – 2 Zones 2 Packers

Key Features

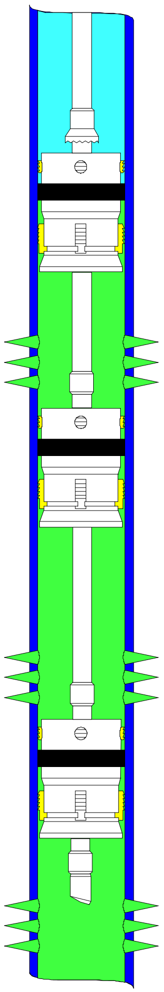
- Independent production through dual tubing strings
- Blast joint protection across upper interval
- Both packers retrievable
- Tailpipe instrument facility on both strings
- Thru-tubing perforation of lower zone possible



Multiple Zones – 3 Zones 3 Packers

Key Features

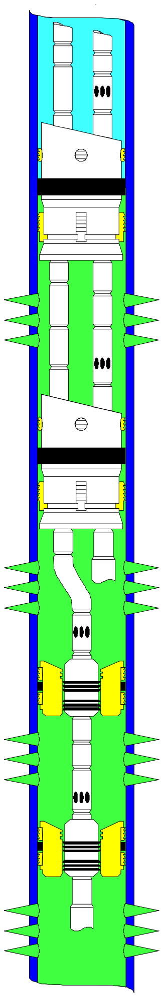
- Several zones produced through one tubing string
- Flow controlled by wireline retrievable choke/check valves
- By-pass sliding sleeve prevents communication during service work
- Up to five zones have been produced using this method



Multiple Zones – 4 Zones 4 Packers

Key Features

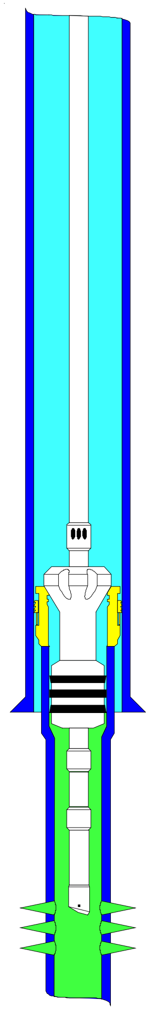
- Four zone selective production system
- Dual production strings
- Commingled or alternate production controlled by sliding sleeves
- System contains 28 major downhole components



Liner CSR

Key Features

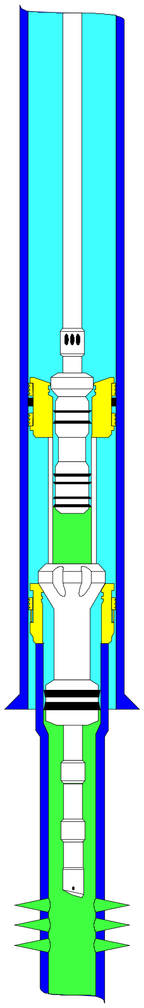
- Most simple liner hook-up
- CSR replaces packer
- Fluid circulation through sliding sleeve above the liner hanger
- Tailpipe retrieved with production tubing



CSR and Seal-Bore Packer

Key Features

- Liner top/lap is permanently isolated
- Fluid circulation through sliding sleeve above the packer
- Tailpipe can be plugged to allow retrieval of the production tubing



Special Service Completions

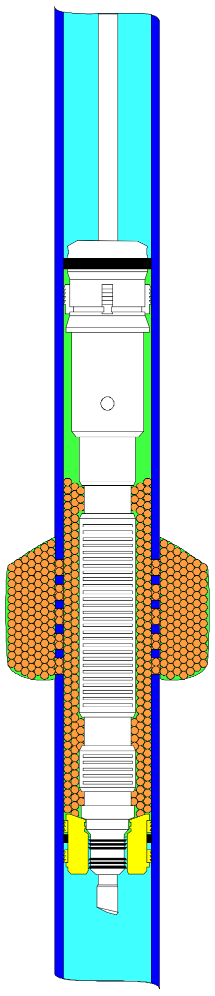
Special completion examples include:

- Sand control
- Inhibitor injection
- Waterflood
- Tubing/casing repair

Gravel Pack Completion

Key Features

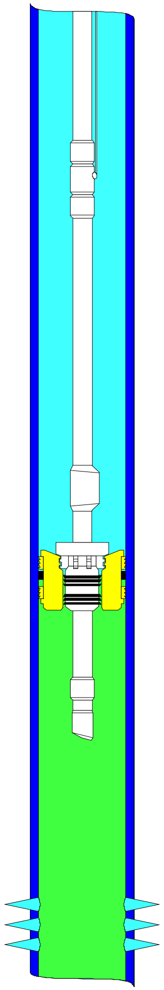
- Tools set and gravel placed using a service tool and tubing workstring
- Gravel squeezed into perforation tunnels
- Production tubing stung-in to production seal-assembly
- Specialised service typically involving dedicated service equipment and personnel



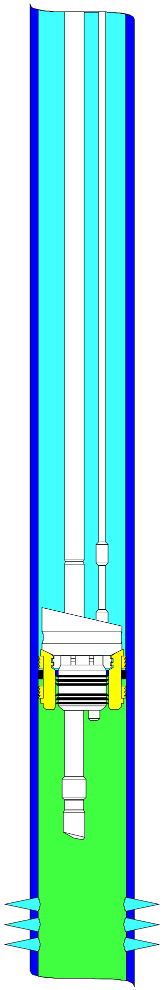
Inhibitor Injection

Key Features

- Side pocket mandrel injection permits protection inside production tubing above the packer
- Injection nipple and small diameter injection line is suitable for shallow applications



Inhibitor – Complete Protection



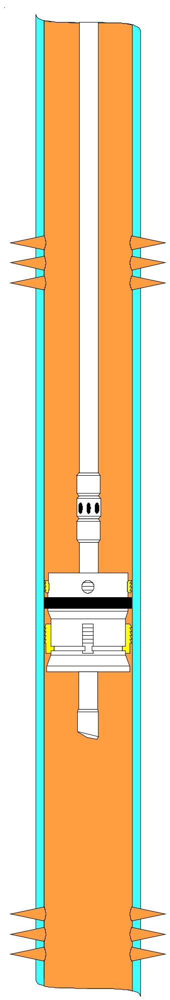
Key Features

- Parallel flow tube and seal-bore packer enables inhibitor to be pumped down short string
- All flow-wetted completion components are exposed to inhibitor fluid
- Inhibitor flow controlled at surface

Waterflood

Key Features

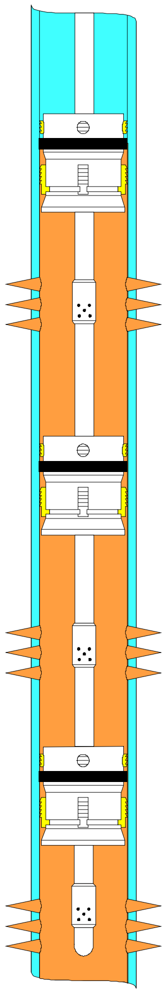
- Two injection zones treated with both flow control regulators located at surface
- Totally separate injection systems



Waterflood – Thick Injection Zone

Key Features

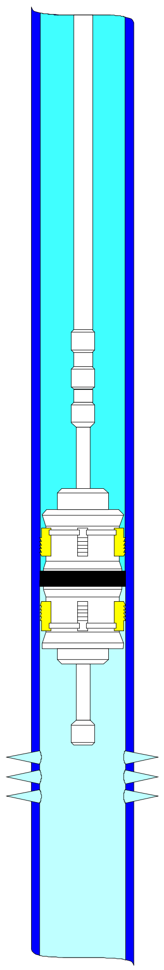
- Injection efficiency in thick zones is improved by using multiple injection points
- Downhole flow regulation helps prevent premature breakthrough between intra-zonal sections



Thermal Completion – Steam Injection

Key Features

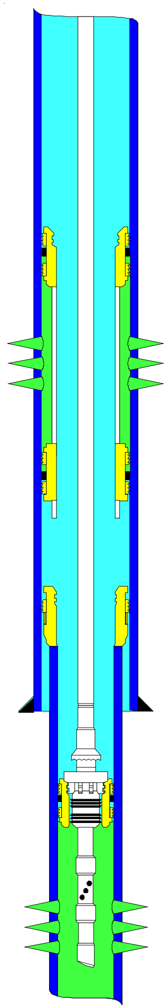
- Packer incorporates an integral expansion/slip joint assembly
- SPM allows insulation material to be circulated into annulus



Remedial Completion – Scab Liner

Key Features

- Isolation of damaged casing/liner or abandonment of a depleted zone
- Hydraulic set packers at top and bottom of scab liner
- On-off connector on lower seal-bore packer allowed installation with the lower perforations isolated throughout the operation



Monbore Completion

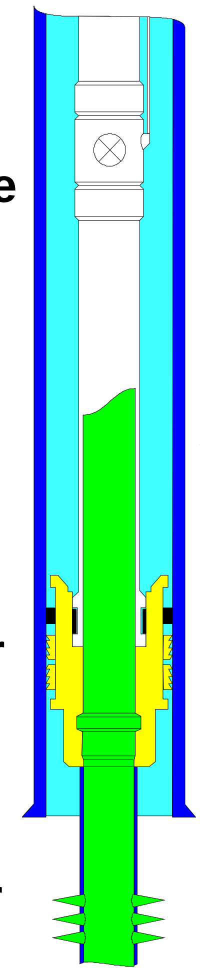
Key Features

- Designed to meet criteria for:
  - appropriate production rates
  - flexibility/contingency
  - safety
  - monitoring (reservoir management)
  - longevity

Safety valve

Packer/hanger assembly

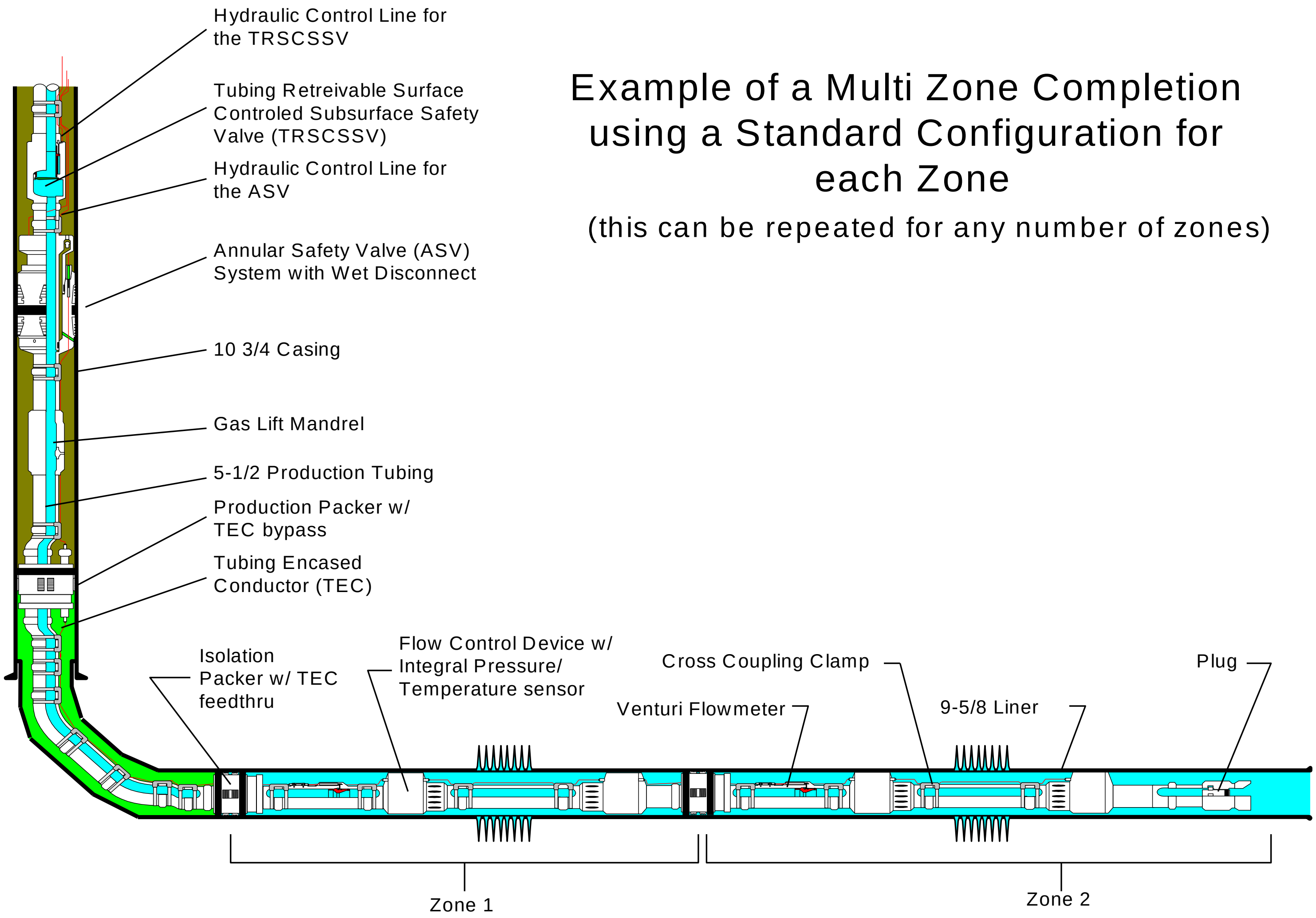
Liner



Multi-Zone Completion

Example of a Multi Zone Completion using a Standard Configuration for each Zone

(this can be repeated for any number of zones)



Artificial Lift – Objectives

The primary purpose of installing an artificial lift system is to maintain a reduced bottom hole pressure (drawdown) to enable the desired reservoir fluids to be produced at an acceptable rate.

Reasons for Artificial Lift

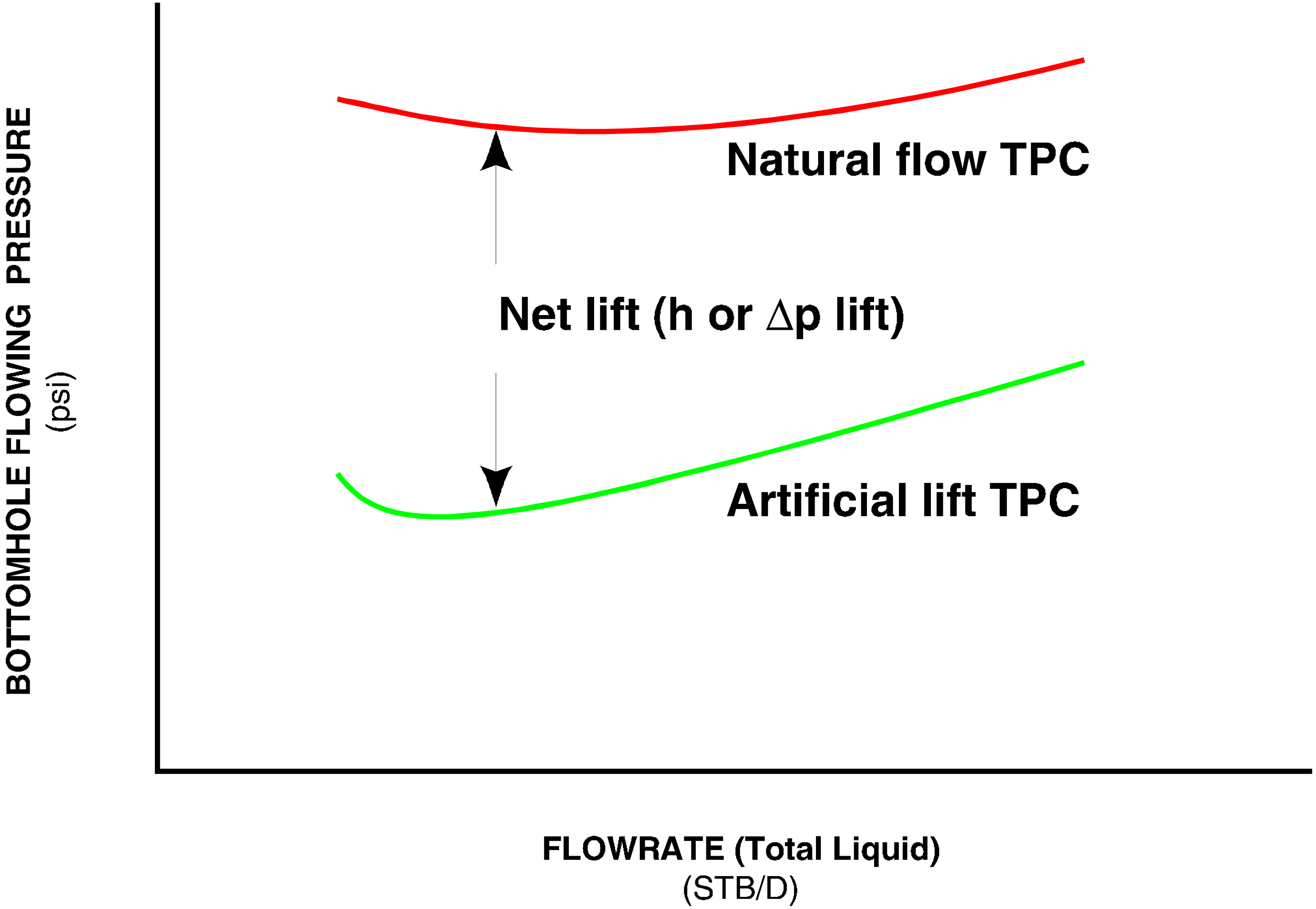
- Compensate for declining reservoir pressure
  - i.e., maintain an acceptable production rate
- Offsetting the effect of increasing water production
- Overcome high friction pressures associated with the production of viscous or waxy crudes
- Kick-off high gas-liquid ratio wells that die when shut in
- Reduce the effect of flowline back pressure
- Maintaining a production rate which reduces wax or scale deposition

Artificial Lift Selection

The selection of an appropriate (optimal) artificial lift system is dependent on:

- Inflow performance of the well/reservoir
- Capacity and operation of the artificial lift system(s)
- Capital cost
- Operating cost
- Servicing frequency (maintenance cost)

Artificial Lift – TPC



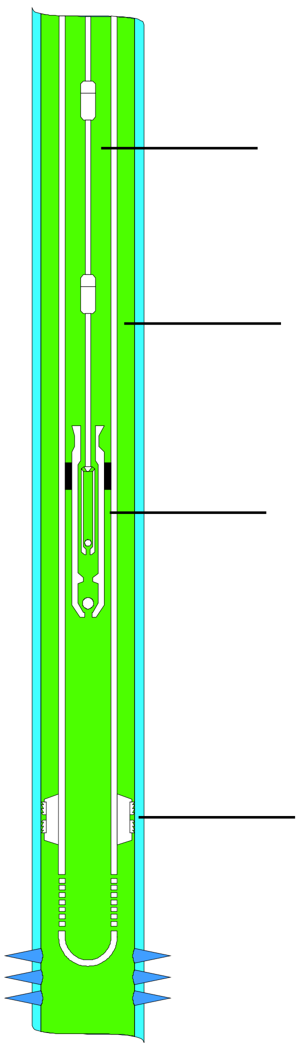
Artificial Lift Methods

Commonly used artificial lift methods include:

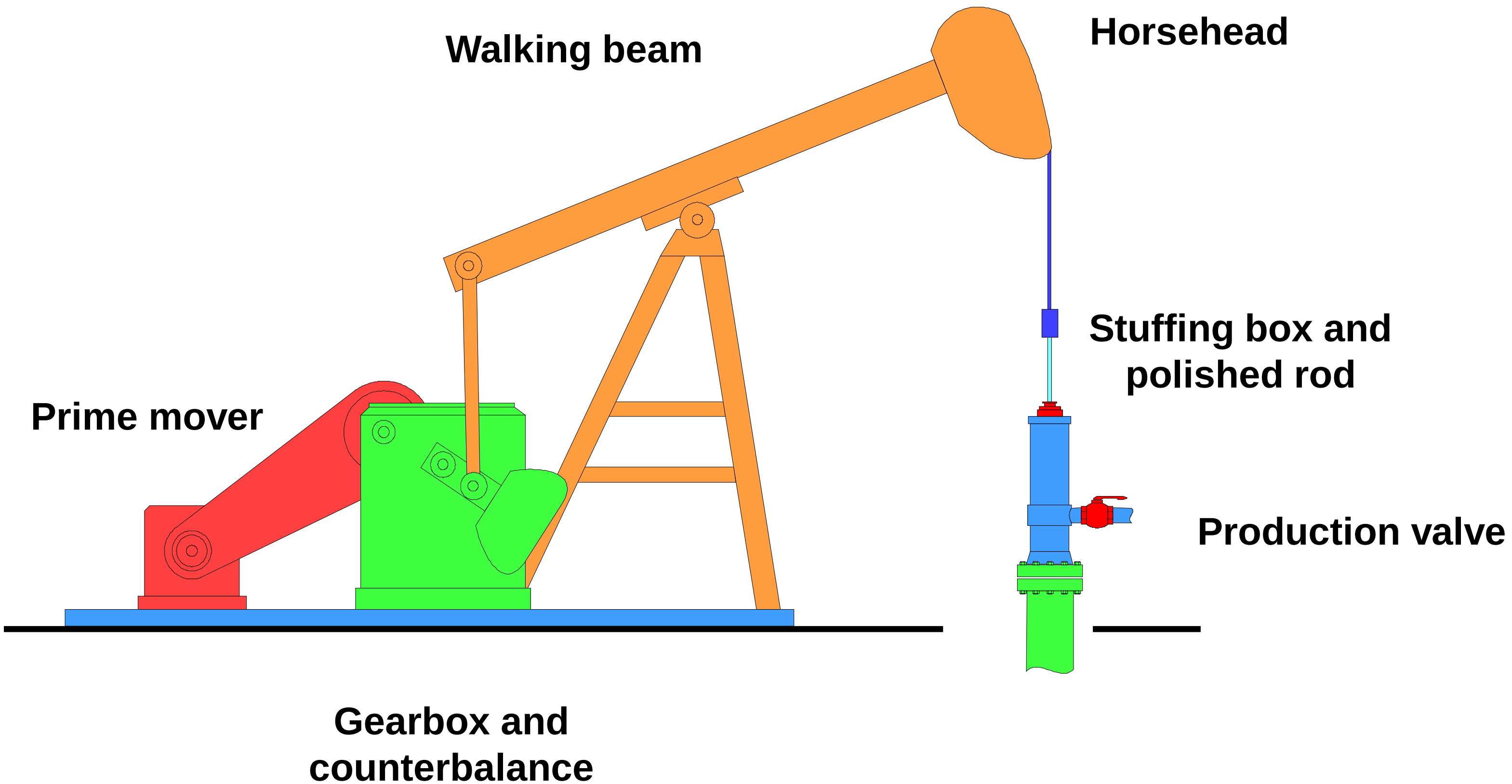
- Rod pump
- Gas lift
- Electric submersible pump
- Piston pump
- Jet pump
- Plunger lift
- Other specialist or adapted systems

Rod Pump

- Rod pumps account for approximately 60% of onshore artificial lift completions
- Industry accepted
  - Economic in ideal field
  - Not gas dependent
- Limited efficiency
  - Maintenance intensive
  - Vertical wellbores

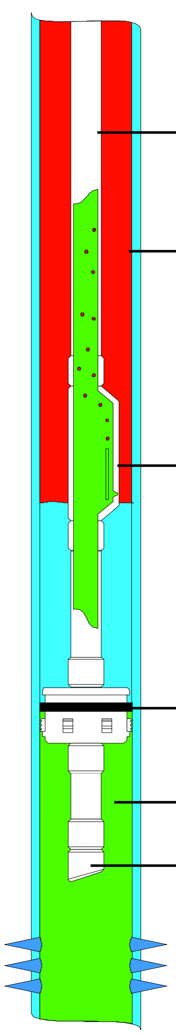


Rod Pump - Surface Equipment



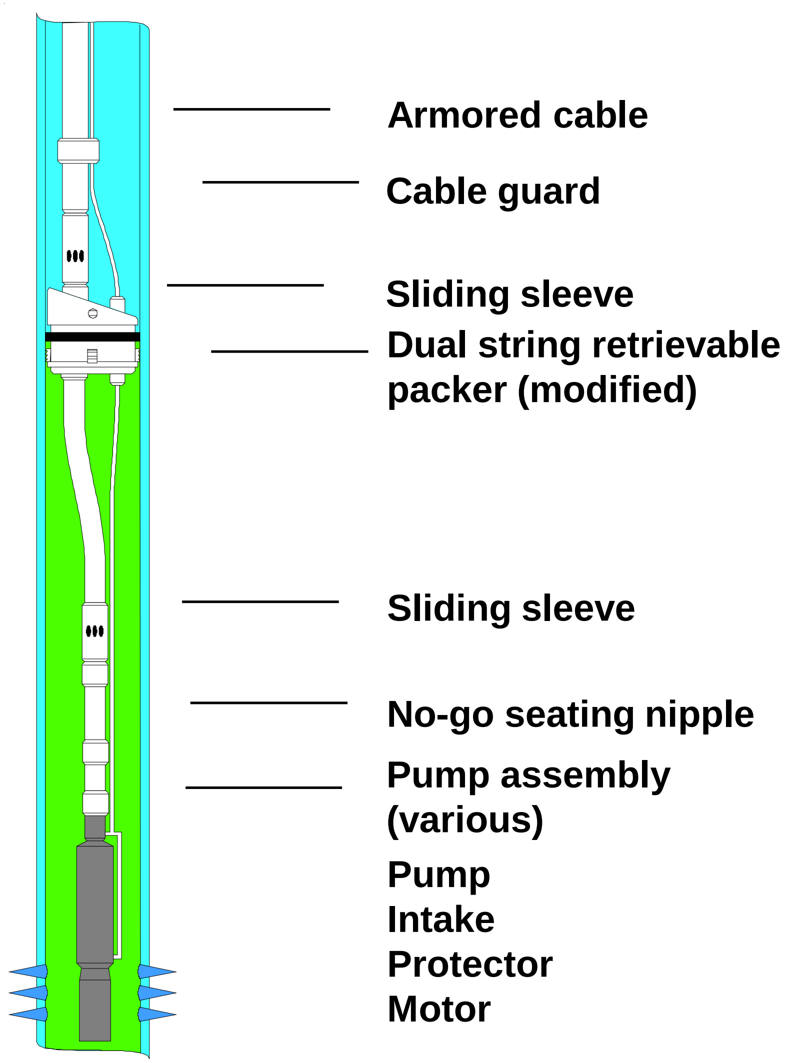
Gas Lift

- Gas lift accounts for approximately 90% of offshore artificial lift completions
- System may be designed to suit most wells
- Wireline serviceable
- Few mechanical parts
- Sand and fill tolerant



Electric Submersible Pump

- Extremely high liquid production capability
- High installation and operating cost
- Suitable for low gas-to-oil ratio applications only
- Electrical components easily damaged



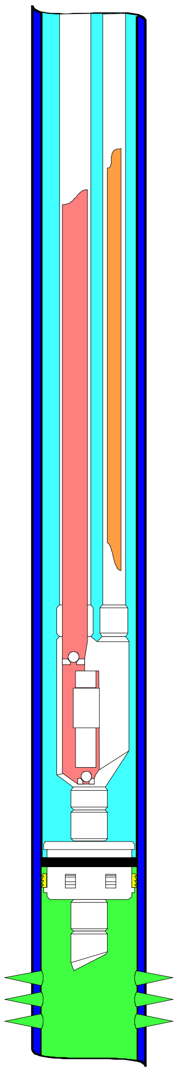
Hydraulic Systems

Hydraulic pumping systems - two main categories

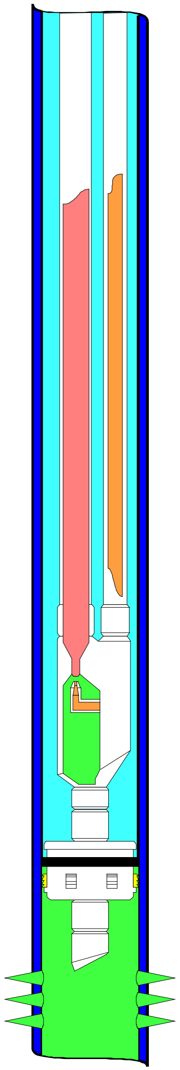
- Piston pump
  - close coupled engine/pump assembly with positive displacement pump
  - performance determined by the pump/engine size
- Hydraulic jet pump
  - imparts energy to the production fluid
  - relatively tolerant of lower quality power fluid or produced fluids

Hydraulic Pumping Systems

Piston pump system



Jet pump system



Plunger Lift

- Suited to high GLR wells (low liquid production)
- Efficiency decreases with depth and PI
- Efficiency increase in larger tubing sizes (where liquid slippage is more prevalent)

Other Systems

- Screw pump
  - operates on same principle as PDM
- Turbine pump
  - similar to ESP installations

Plunger Lift System