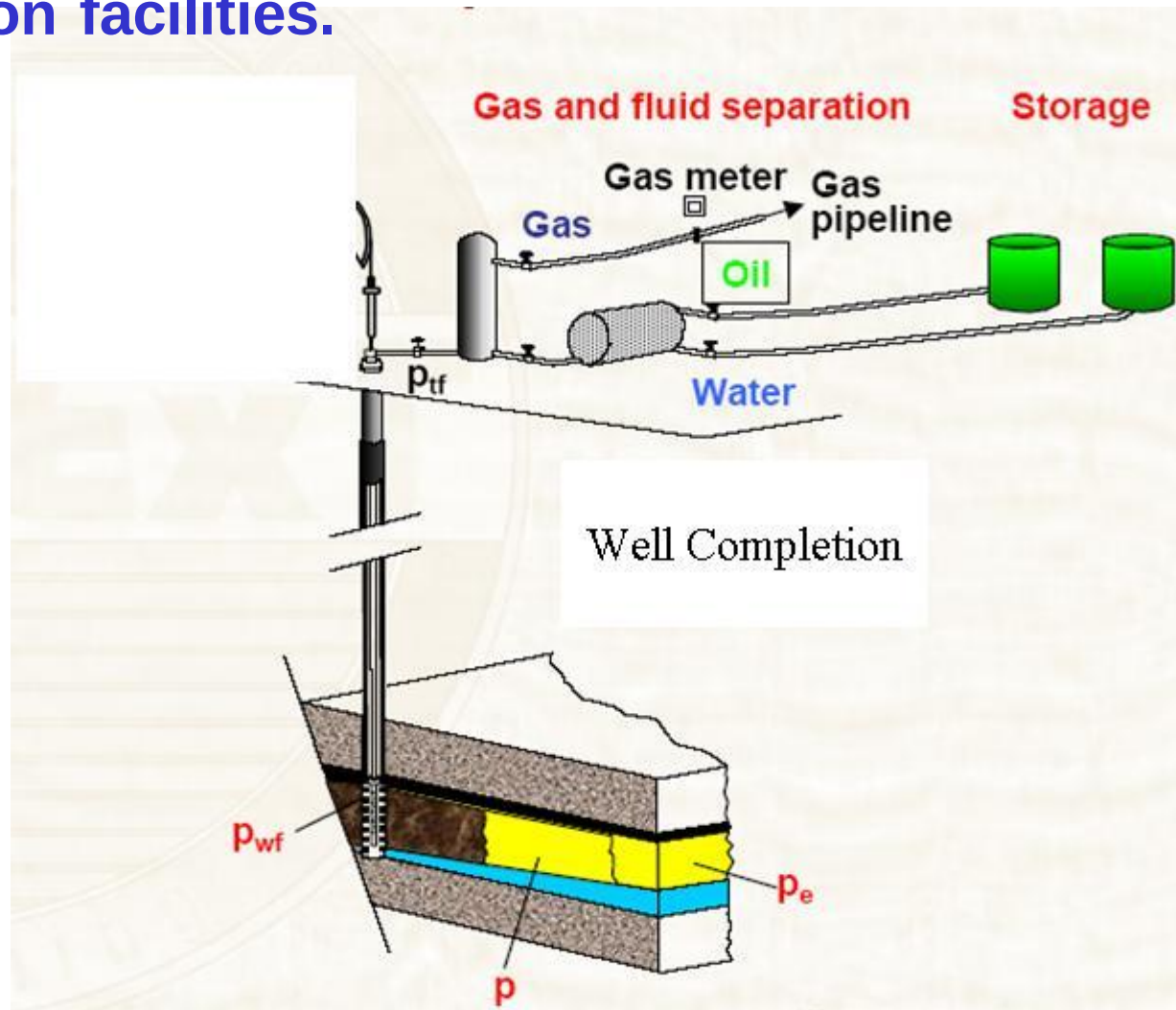
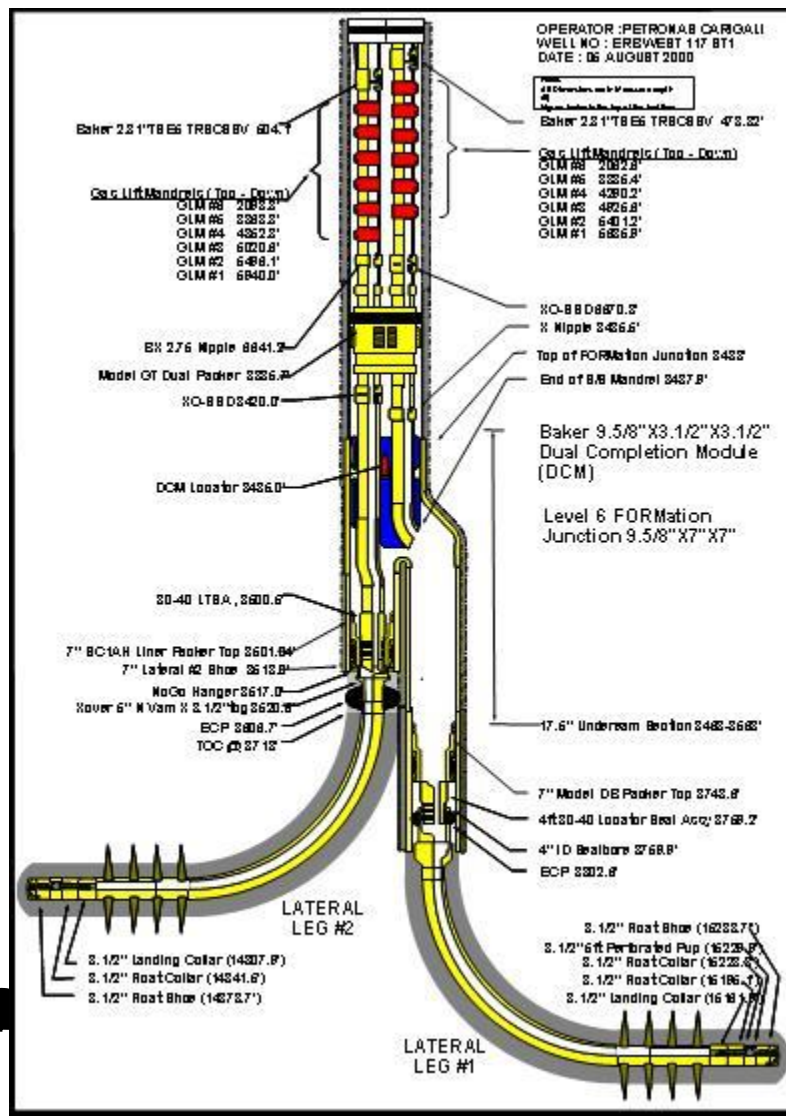
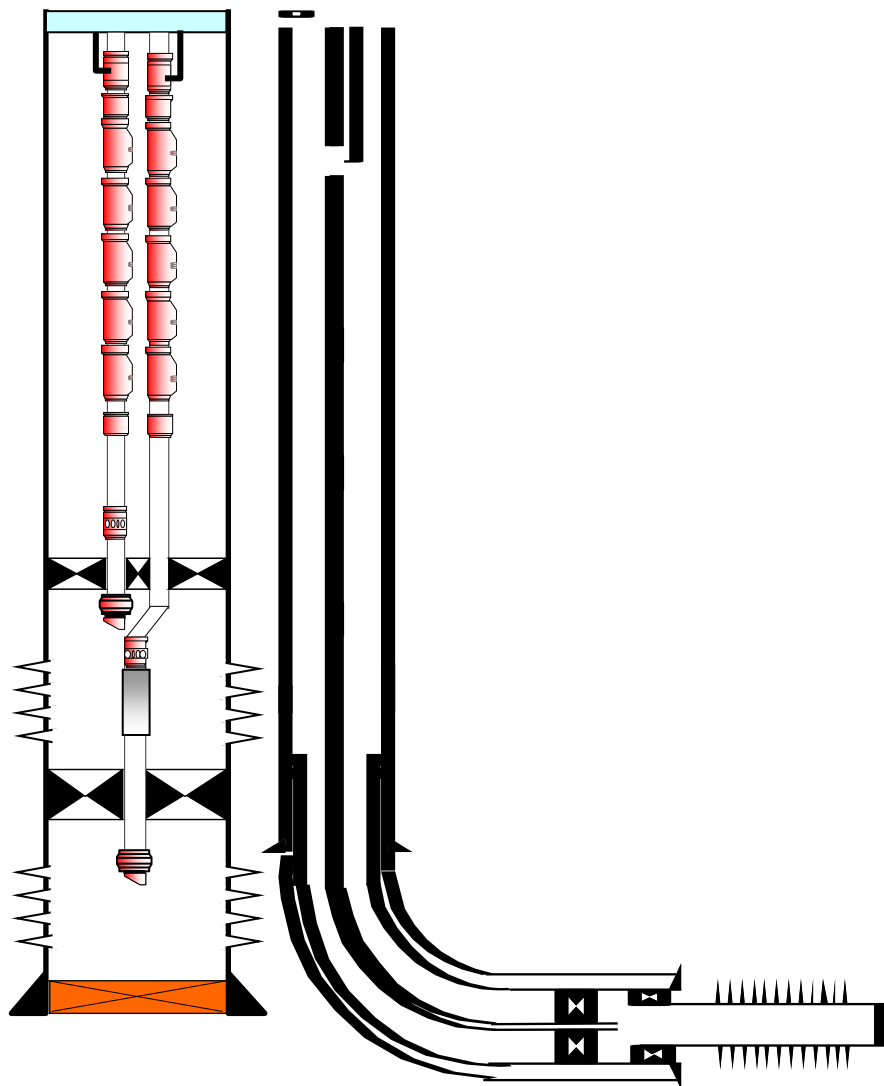


WELL COMPLETION PROGRAM

The purpose of well completion is to provide communication between the reservoir and the surface production facilities.



TYPICAL WELL COMPLETION CONFIGURATION



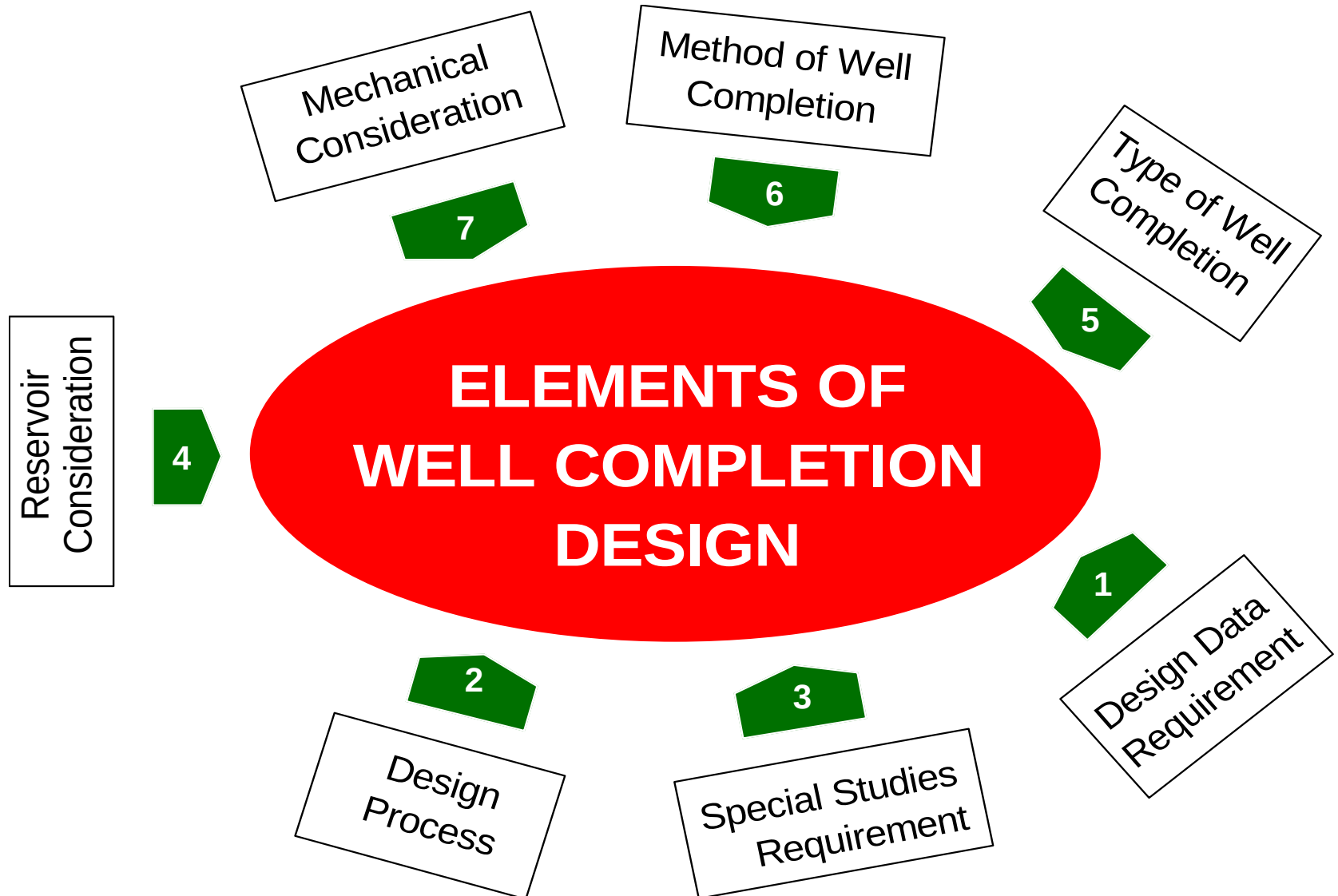
Why well completion is so important ?

- **To effectively drain out the reservoir fluids to surface. Proper completion design is crucial in maximizing recovery.**
- **To provide subsurface and surface flow control and safety. Several zones could be produced selectively or commingle it.**
- **Isolate gas and water zones.**
- **To support wellbore and avoid excessive sand production.**

The well completion provides :

- **Pressure control**
- **A replaceable conduit for produced fluids**
- **Selectivity of produced intervals**
- **Simple well killing facilities**
- **Potential for the exclusion of solids**

Well Completion Design Consideration



1. Design Data Requirement

Well Testing Data

- **Production rate**
- **Productivity Index, Skin and AOF**
- **Basic Sediment and Water**
- **Reservoir Pressure, P_r**
- **Bottom Hole Flowing Pressure, P_{wf}**
- **Temperature**
- **Gas Oil Ratio (GOR), Gas Lliquid Ratio (GLR) and Watercut (WC)**
- **Type of fluid (oil, gas or water)**
- **Degree API**
- **Viscosity**
- **Density**
- **H₂S, CO₂ content**
- **Fluid composition**

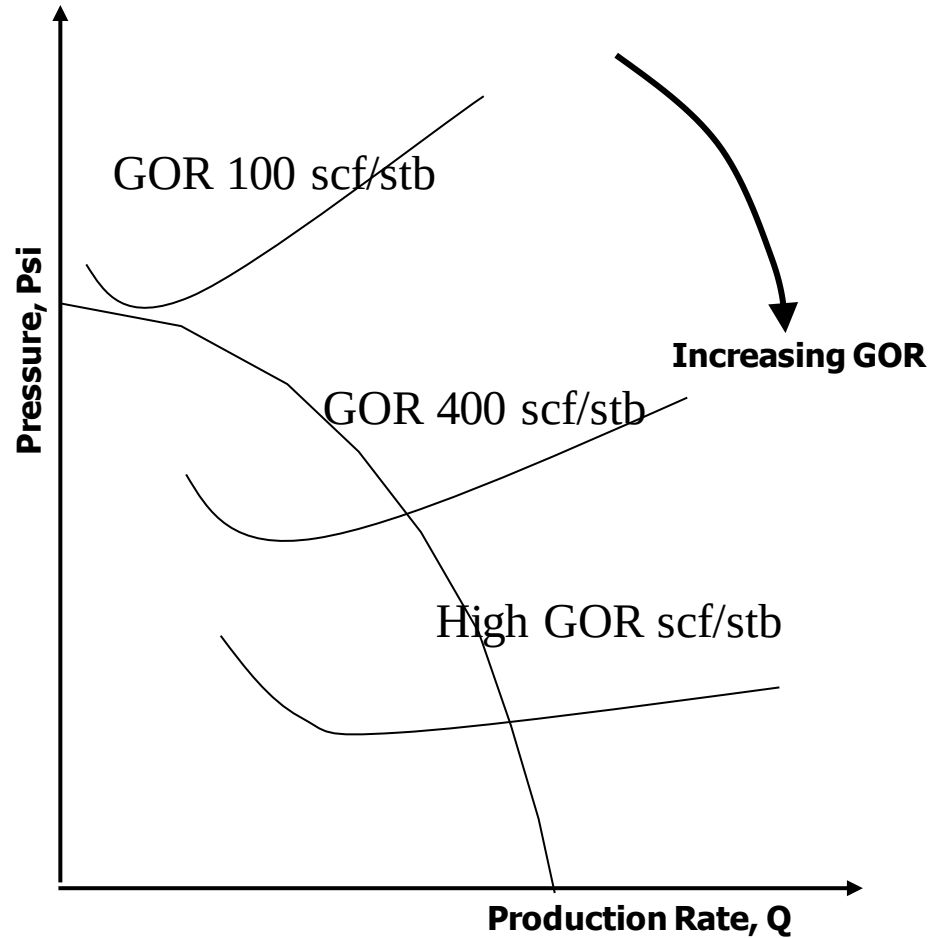
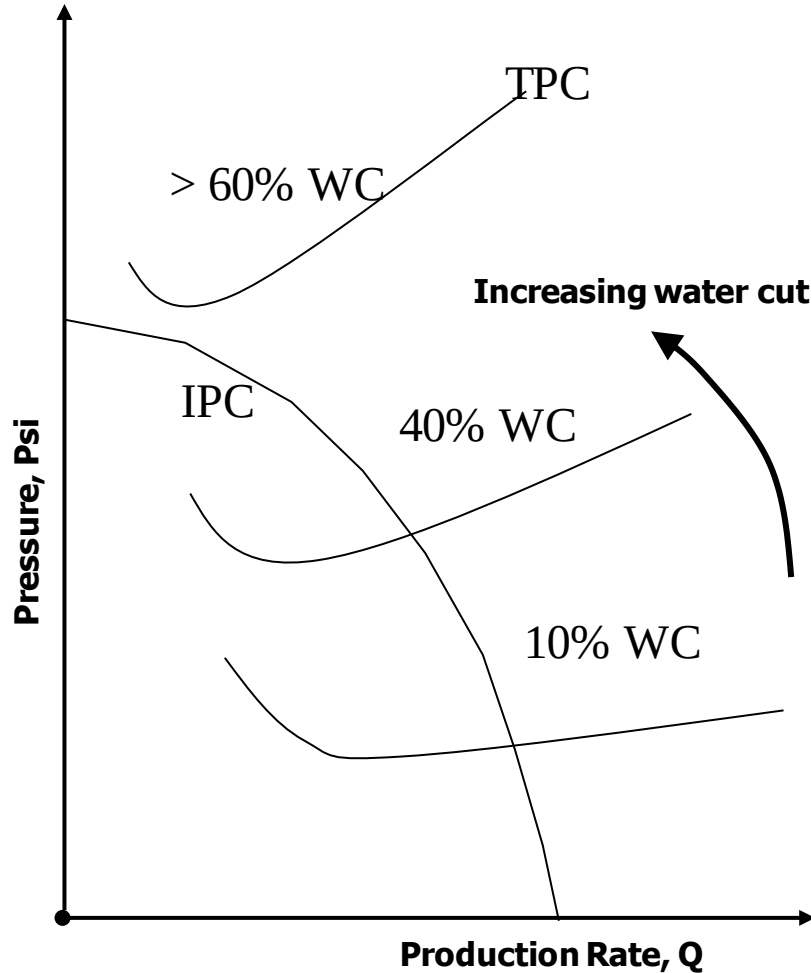
1. Design Data Requirement (cont..)

Reservoir Rock Properties

- **Depth**
- **Thickness**
- **Porosity and Permeability**
- **Capillary pressure**
- **Rock strength (Brinell Hardness Number and compressive strength)**
- **Stresses**
- **Young Modulus**
- **Poissons ratio**
- **Formation grain size (sieve analysis)**

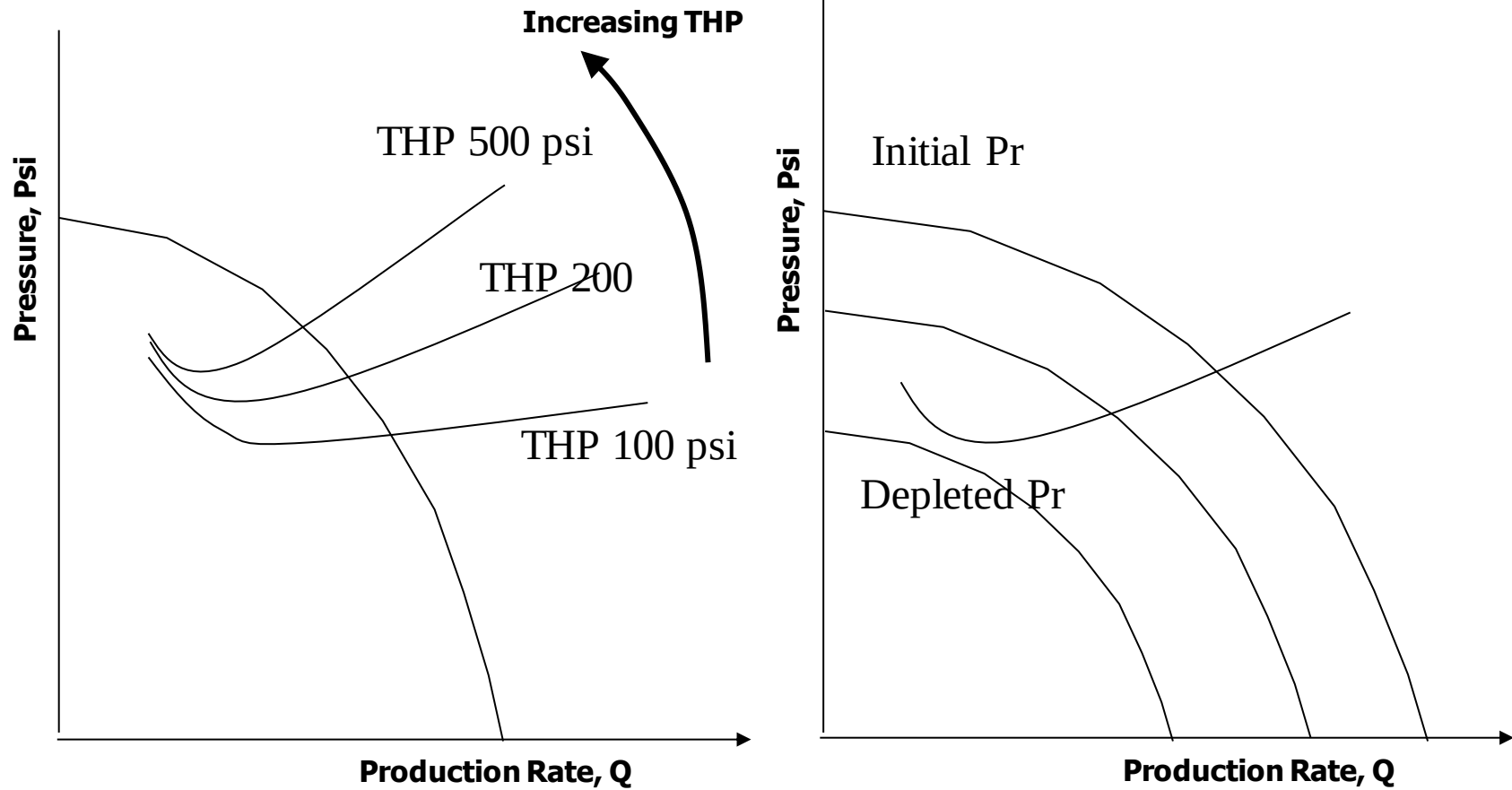
2. Design Process – Tubing Selection

IPR with various Water Cut and GOR sensitivity



Notes: IPR – Inflow Performance Relationship; TPC – Tubing Performance Curve; GOR- Gas Oil Ratio

IPR with THP and Pr Sensitivity



Note: Pr – Reservoir Pressure

Completion Tubing Sizes

Tubing size ranges from 2 3/8"

2 7/8"

3 1/2"

4"

4 1/2"

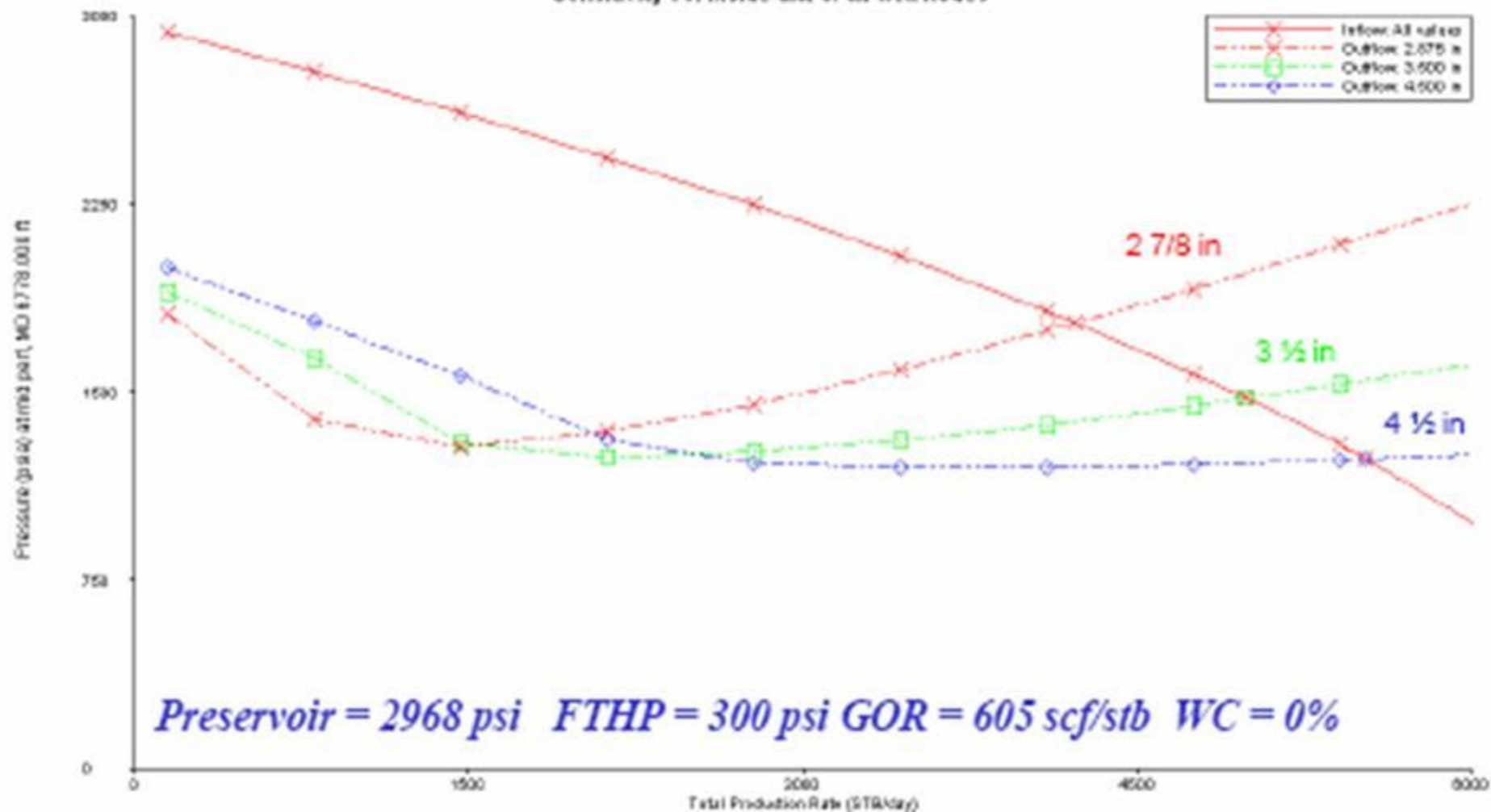
5 1/2"

7"

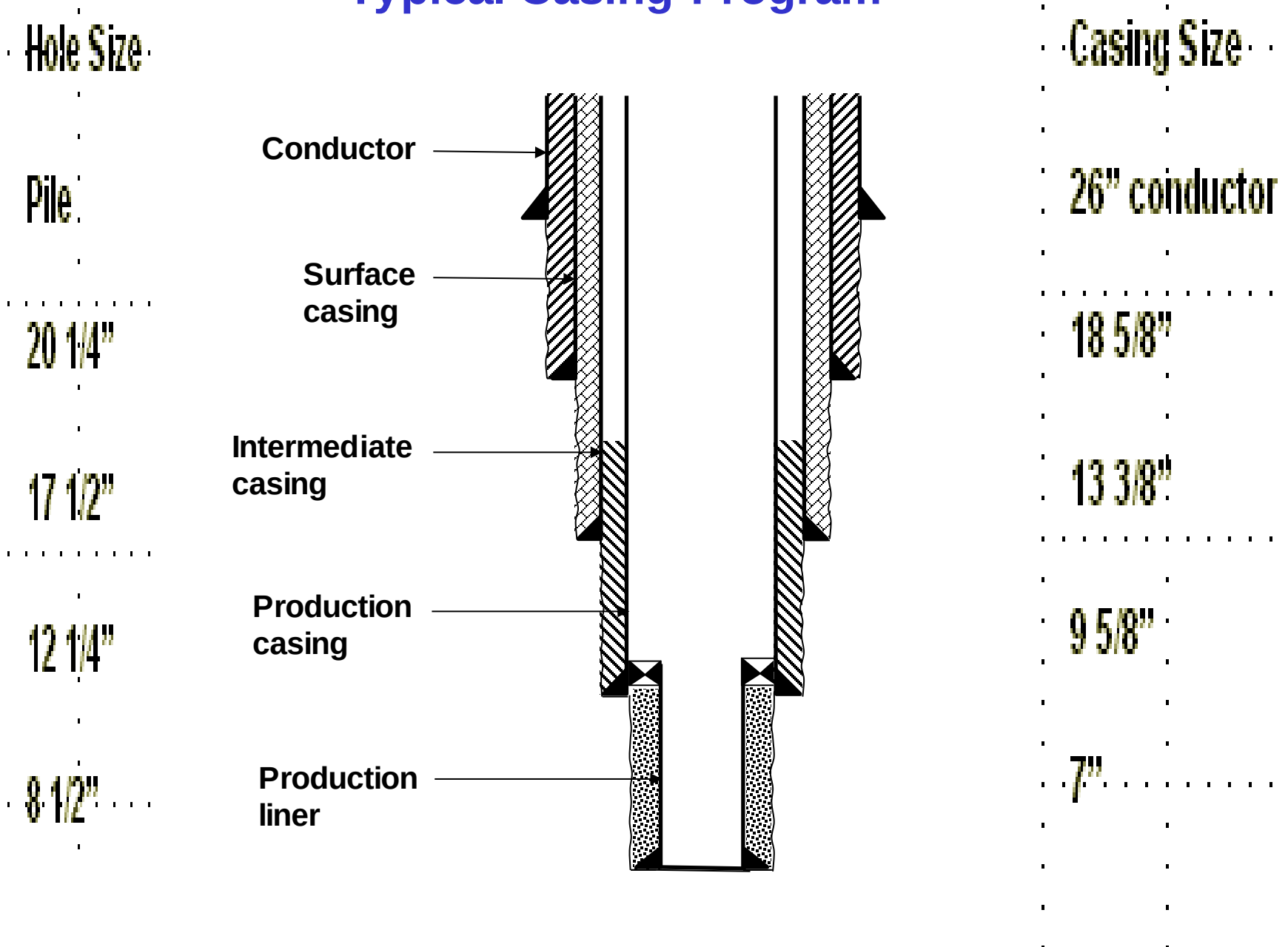
To as large as 9 5/8"

TUBING SIZE SENSITIVITY

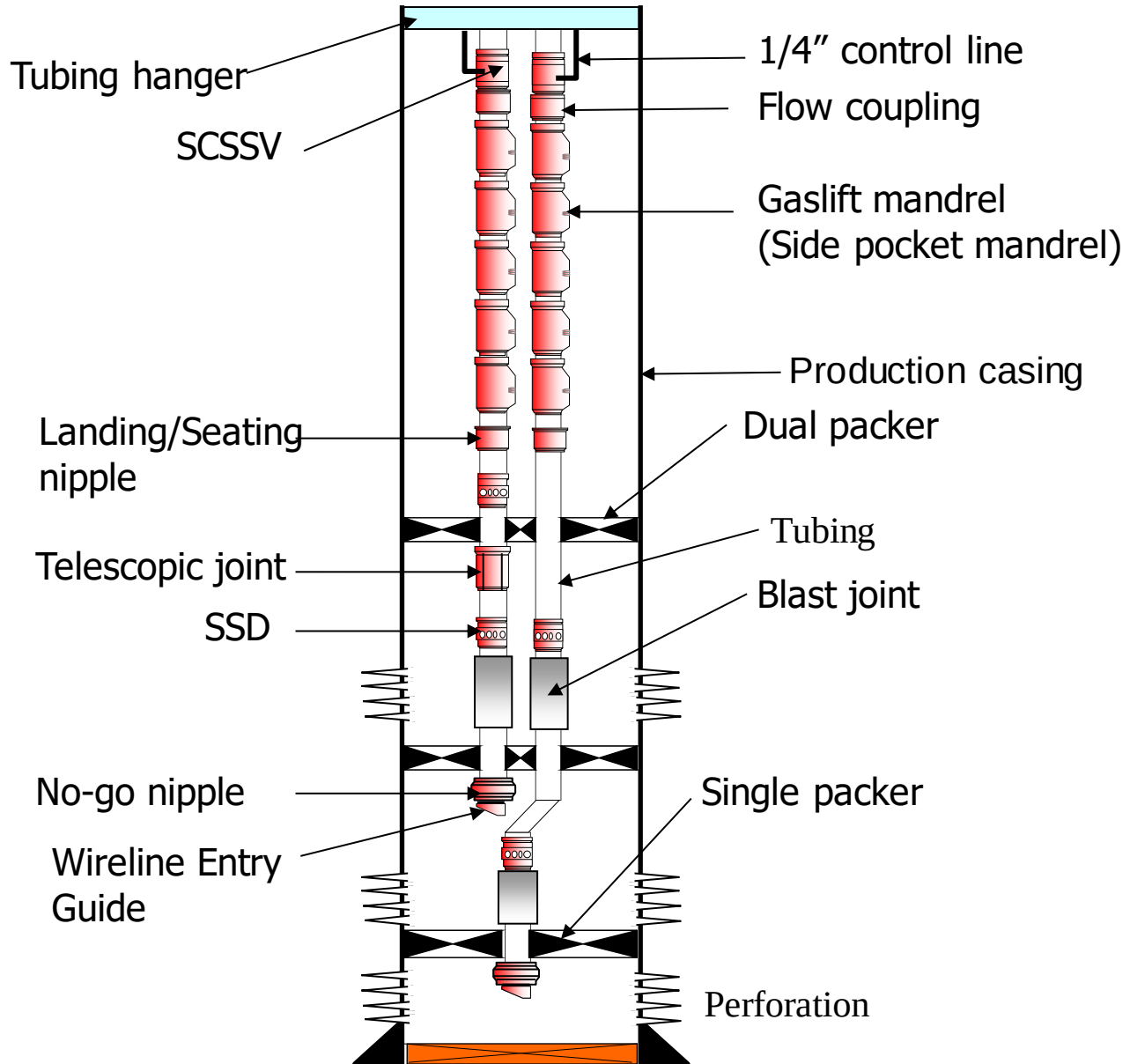
Inflow/Outflow Curves for D21-2ST sand A base case reduce THP
Sensitivity To: Inside dia. of all well nodes



Typical Casing Program



Completion Accessories



3. Special Study Requirement

- **PVT**
- **Core Analysis**
- **Metallurgy**
- **Formation Water/Crude Analysis**

4. Reservoir Considerations

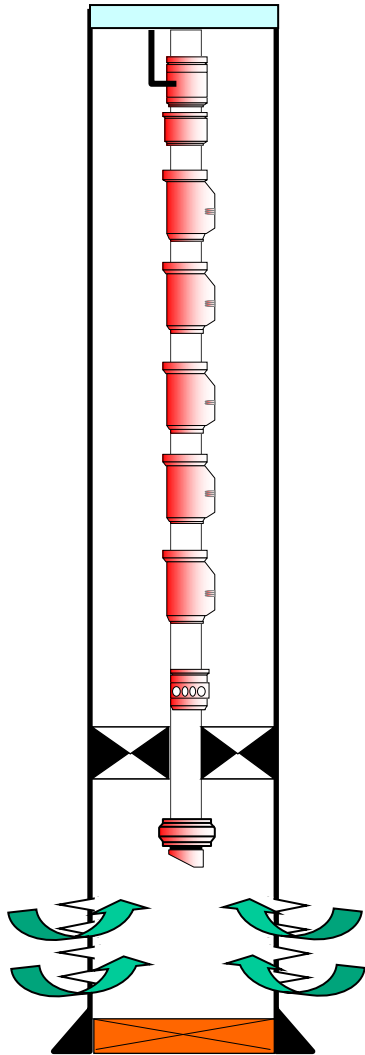
- **Production rate /Inflow performane**
- **Formation strength**
- **Fluid type (corrosion, scale and wax/asphaltene)**
- **Reservoir permeability**
- **Reservoir pressure**
- **No. of reservoirs**
- **Reservoir management**

5. Types of Well Completion

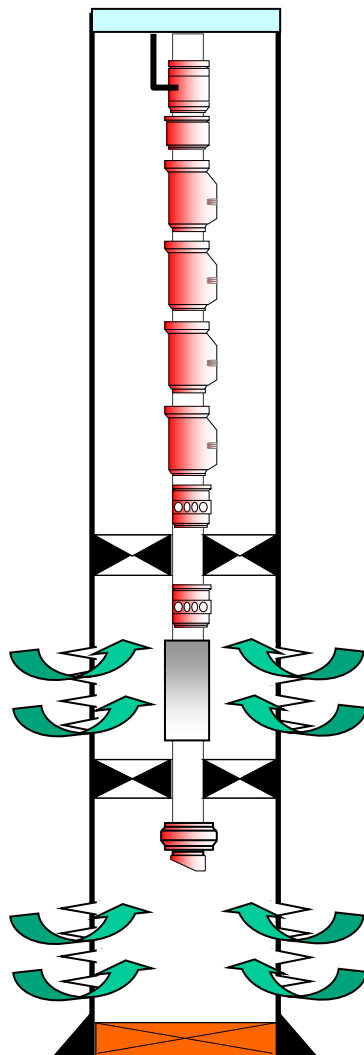
There are various types of well completion :

- **Single string / selective single**
- **Dual string**
- **Gravelpack**
- **slim well**
- **monobore**
- **horizontal**
- **multilateral**
- **twin well / triple well**
- **Y Block completion**
- **smart / intelligent well**

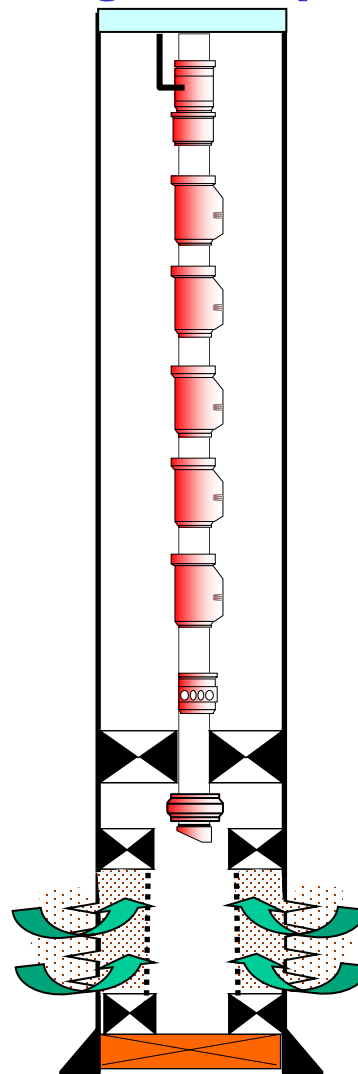
Well Completion: Single String Types With and without gravel packed



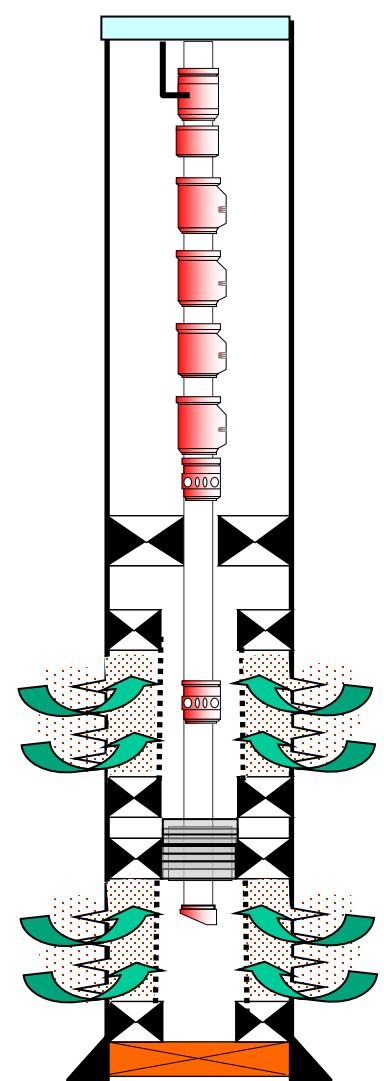
Cased Hole



**Cased Hole
Selective Zone**

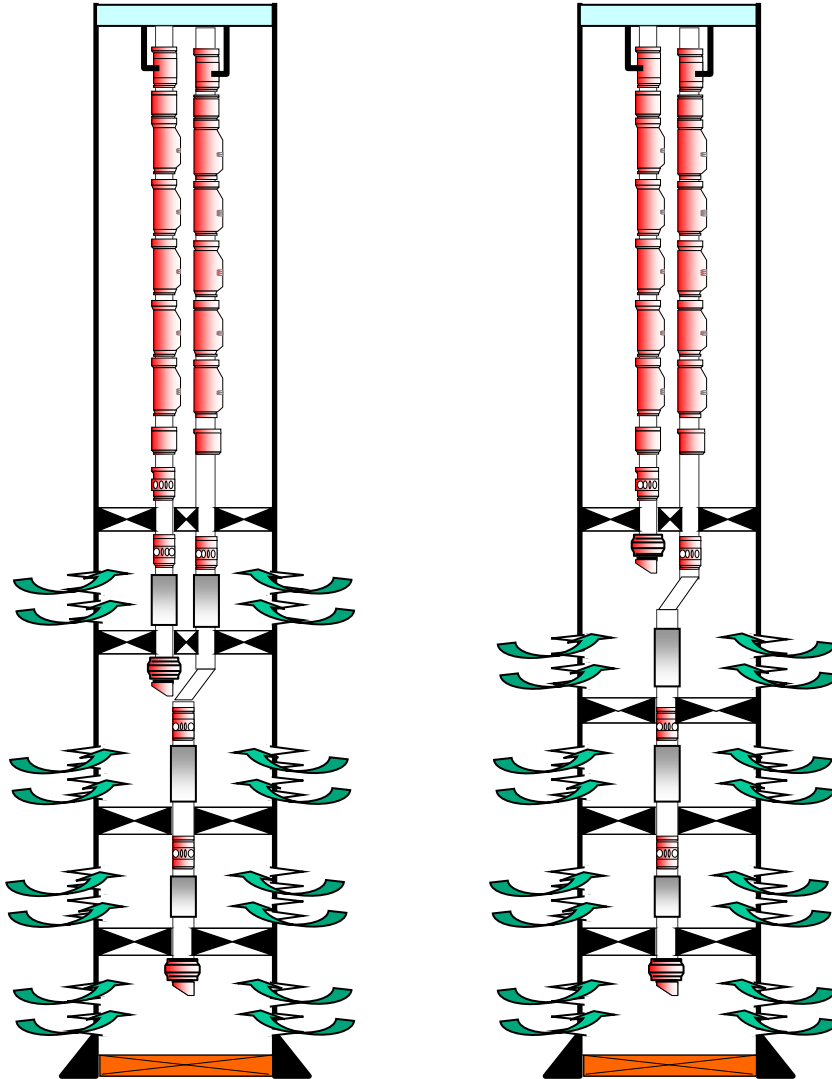


**Cased Hole
Gravel Packed**

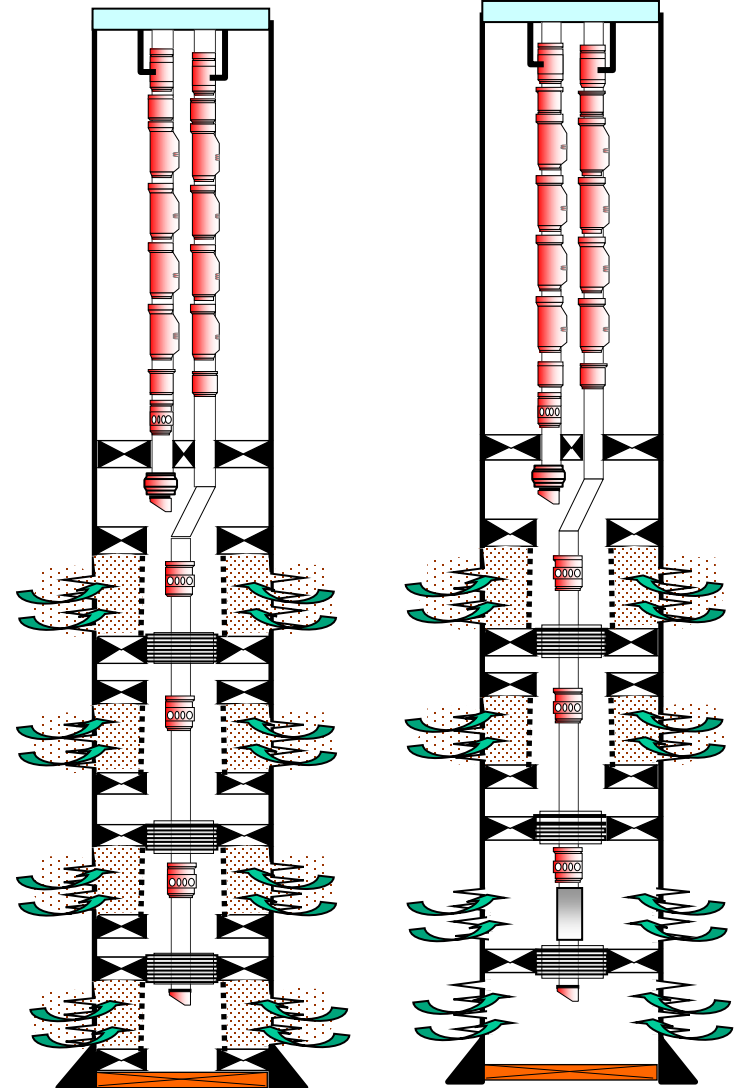


**Cased Hole
Selective Zone
Gravel Packed**

Well Completion Dual Strings Types With & Without Gravel Packed



**Cased Hole No Gravel Packed
Short String Selective/Non Selective**



**Cased Hole With All Gravel Packed/
Only Shallower Reservoirs Gravel Packed**

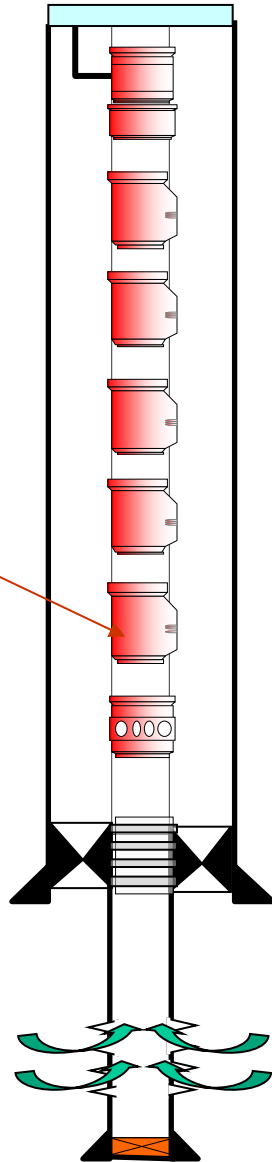
Slim Well

Drilling small hole sizes and completing with smaller casing scheme.

This will enable faster drilling with less casing tubular, cement and associated drilling materials hence lower cost.

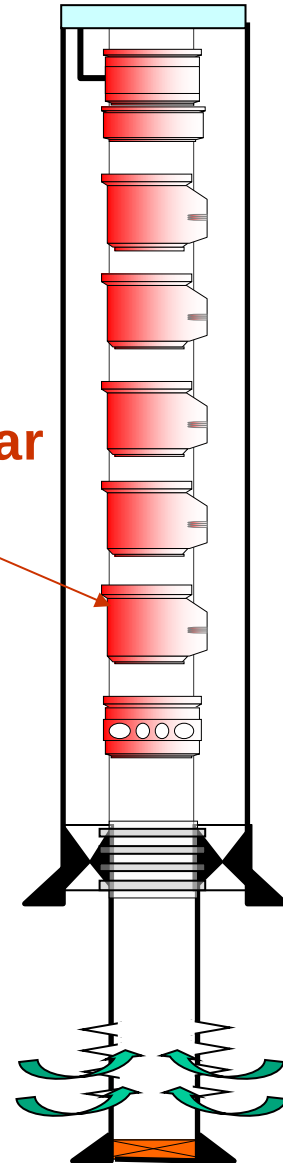
Monobore

(e.g. 3 1/2" tubing
with 3 1/2" liner)

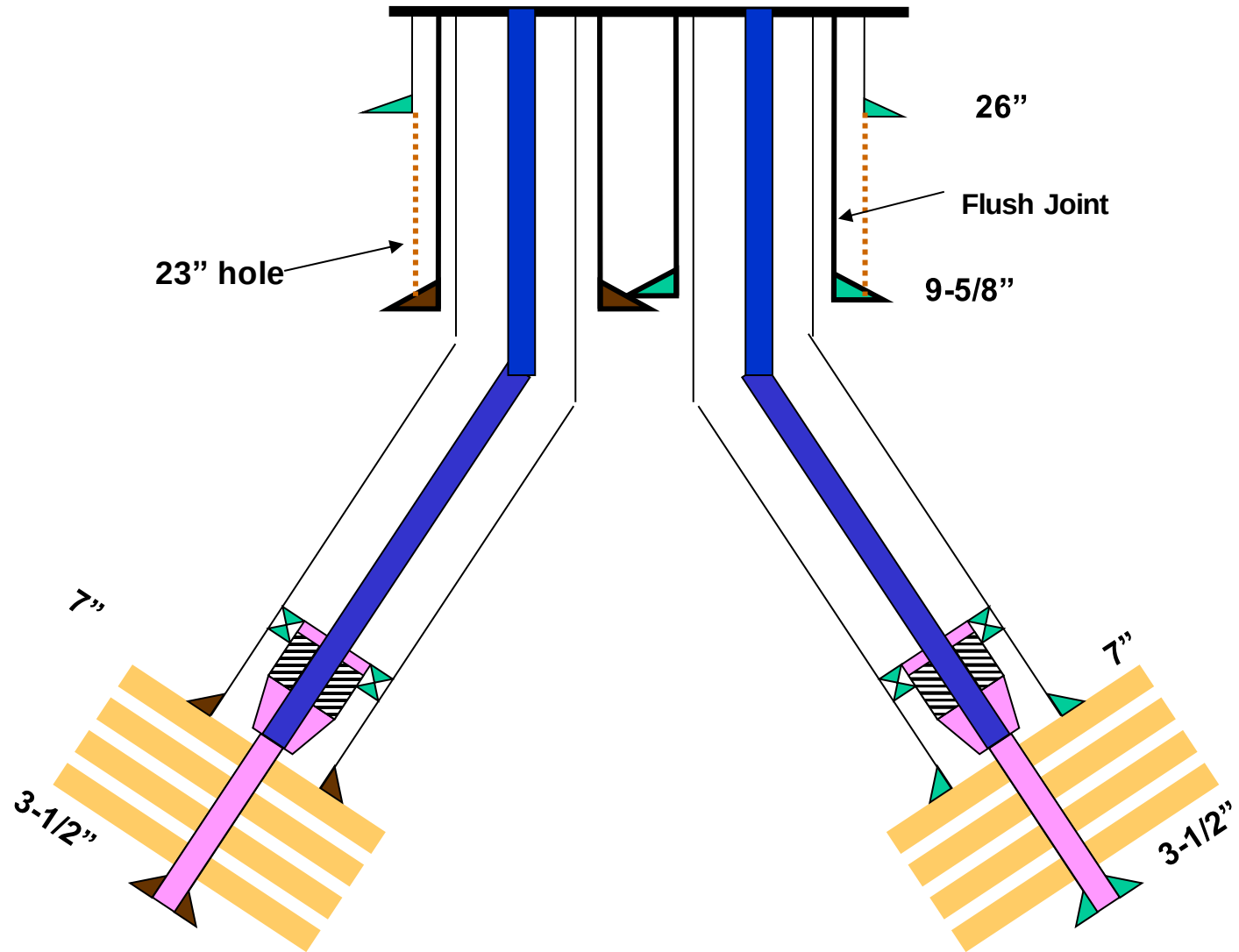


Big bore Monobore

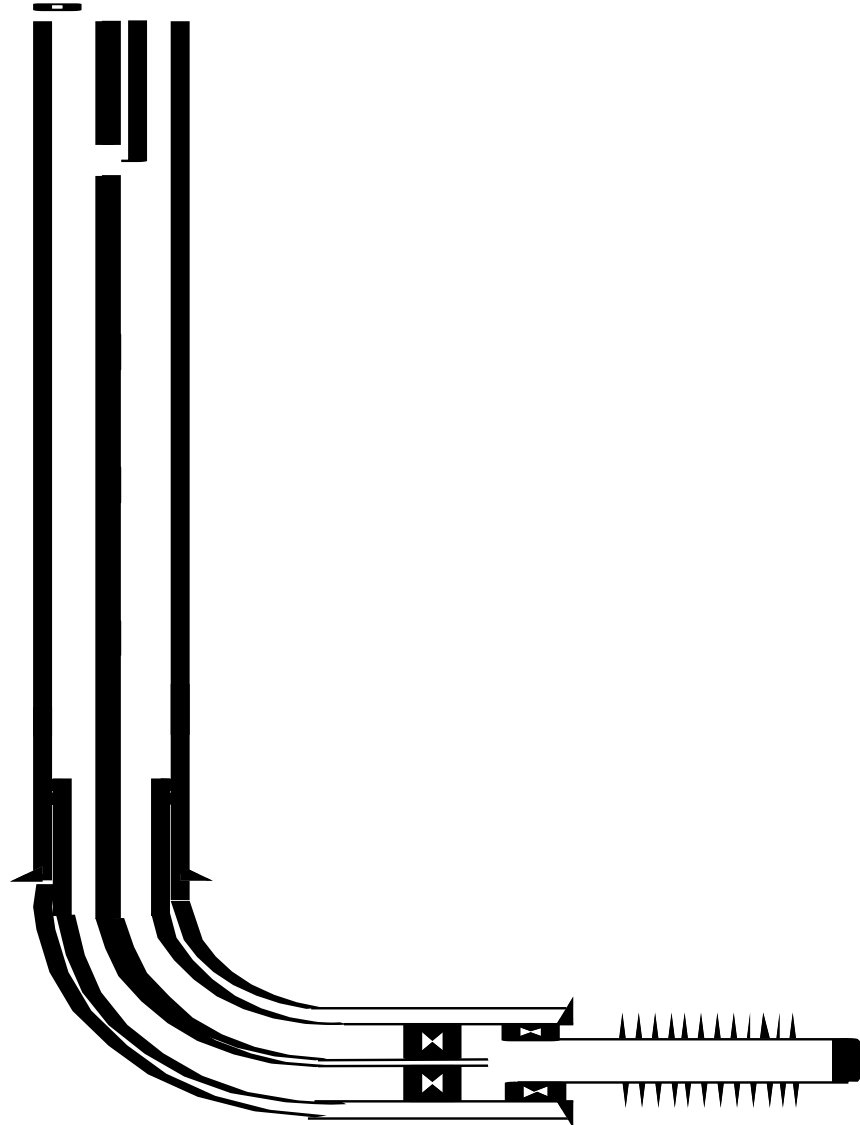
4"-7" tubular



DUAL SLIMHOLE MONOBORE



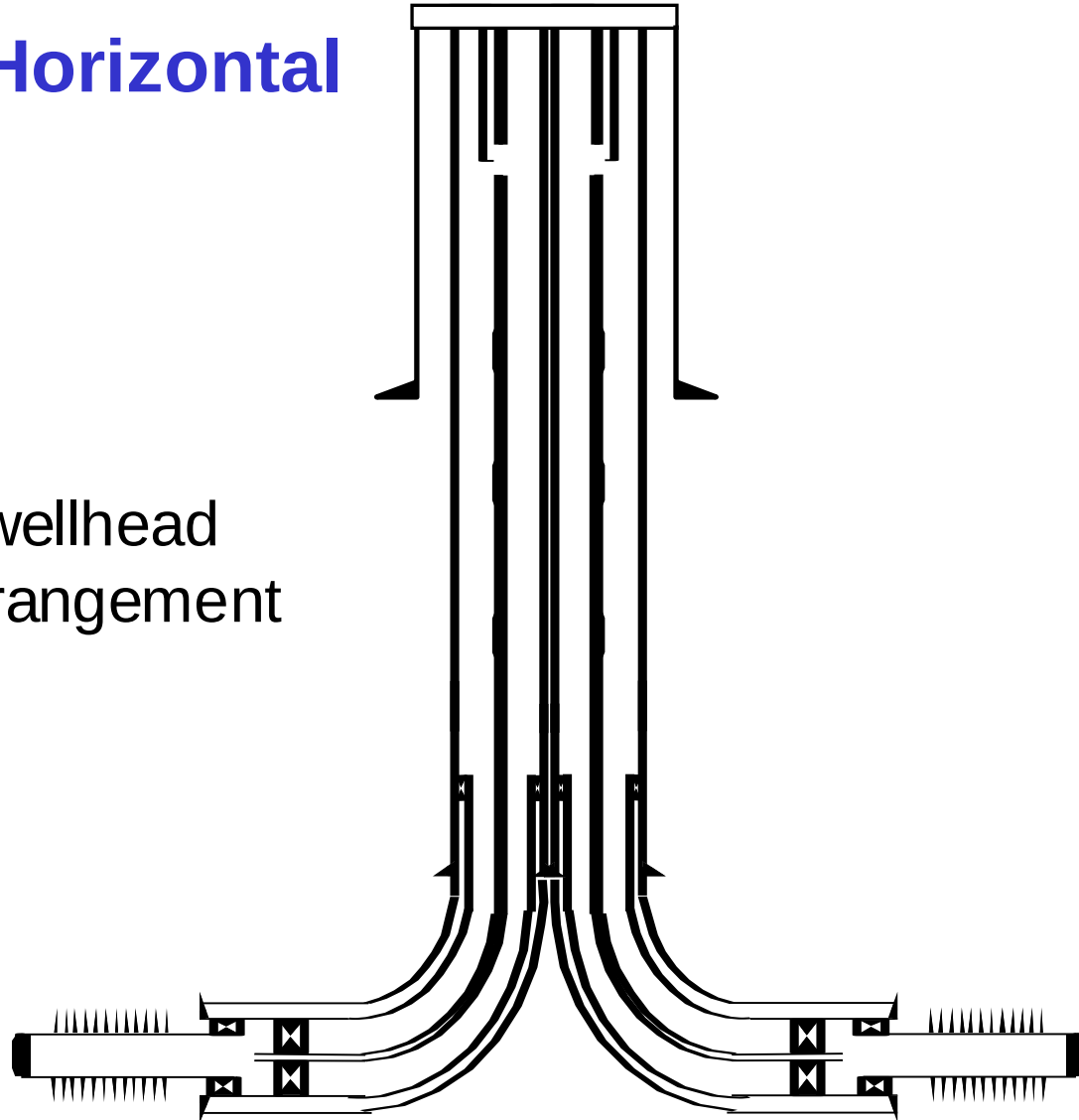
Horizontal Well



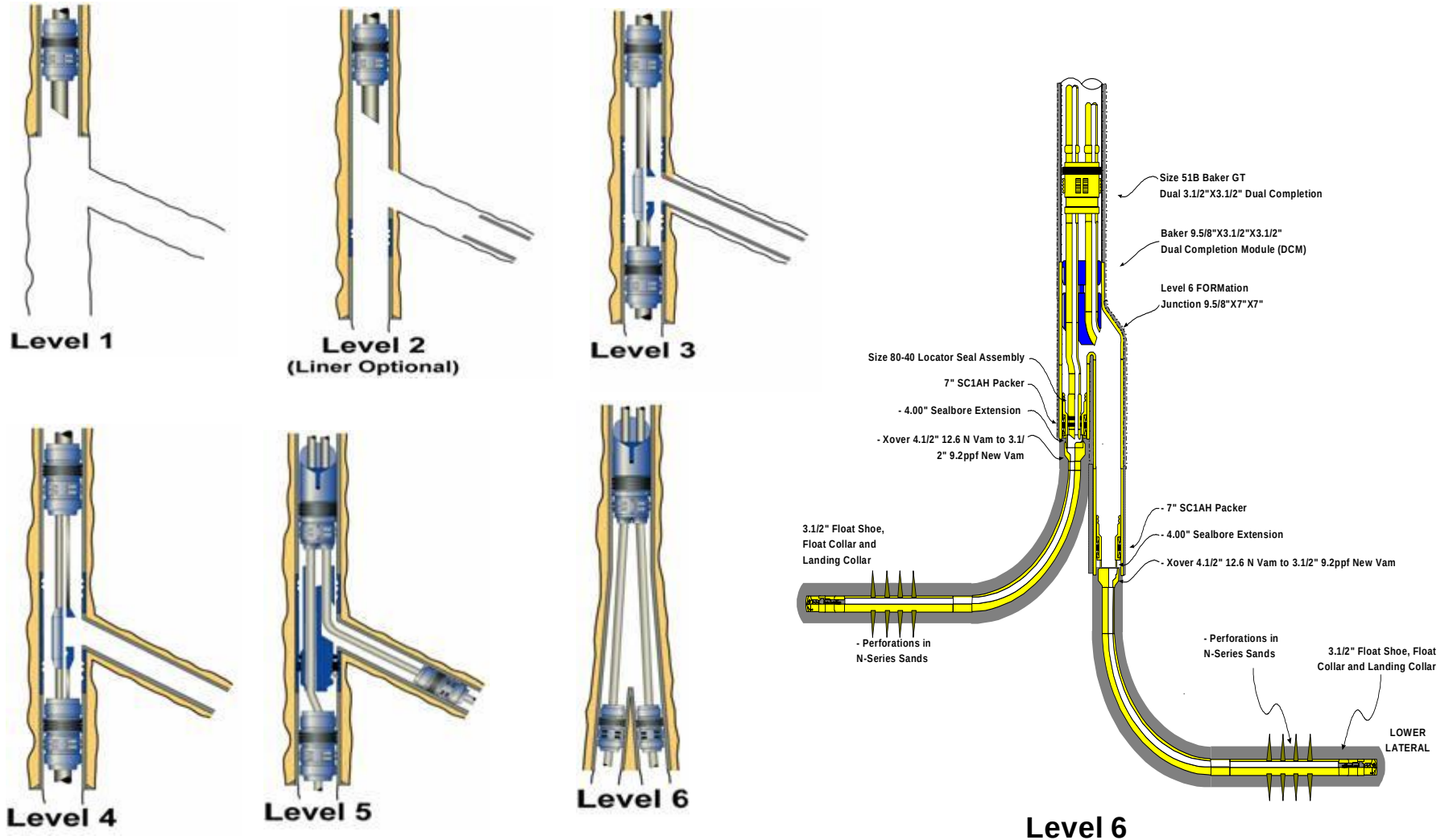
Twin well - Horizontal

Two wells in
one conductor

Requires special wellhead
and x-mas tree arrangement

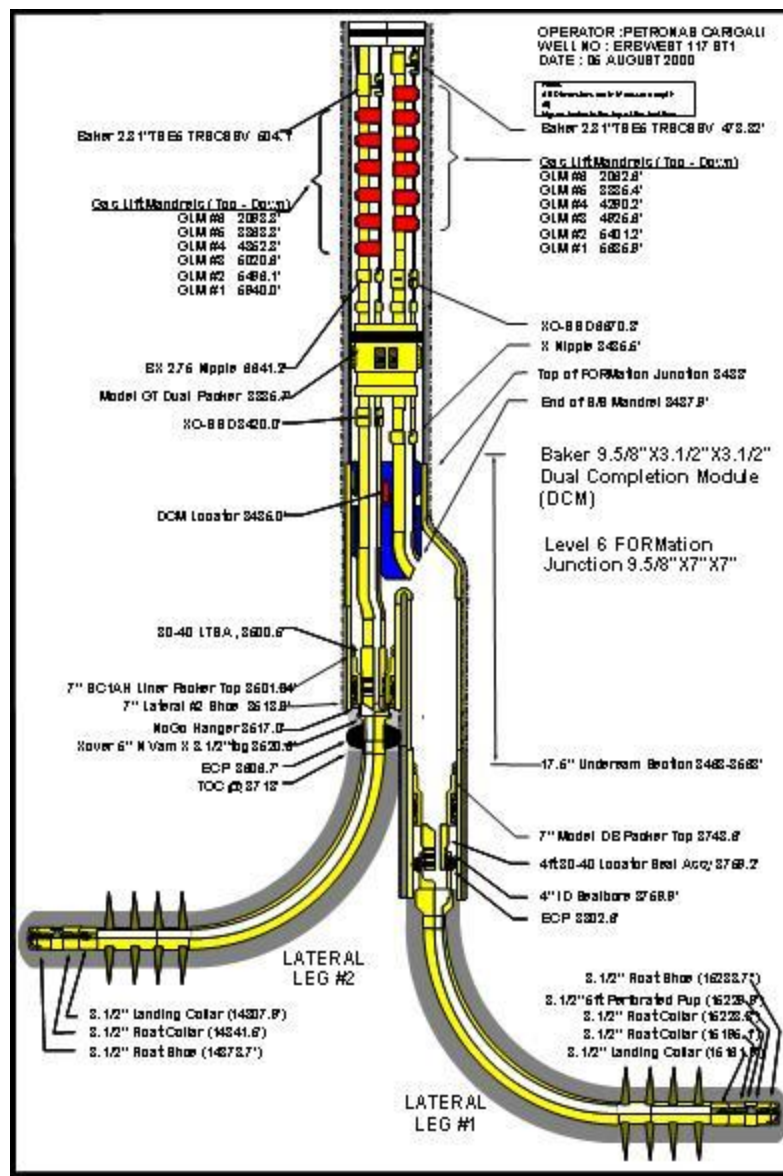


TAML (Technology Advancement MultiLateral)

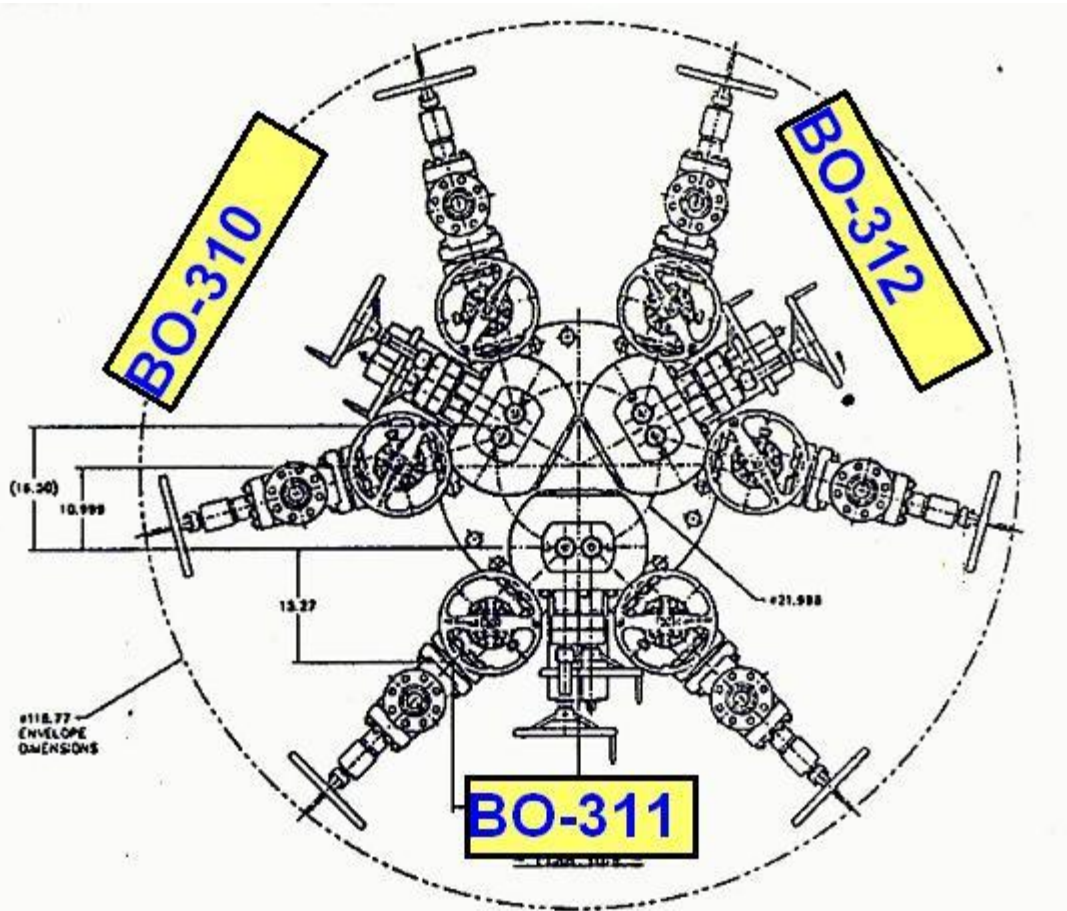


EW-117

Level 6 Multilateral

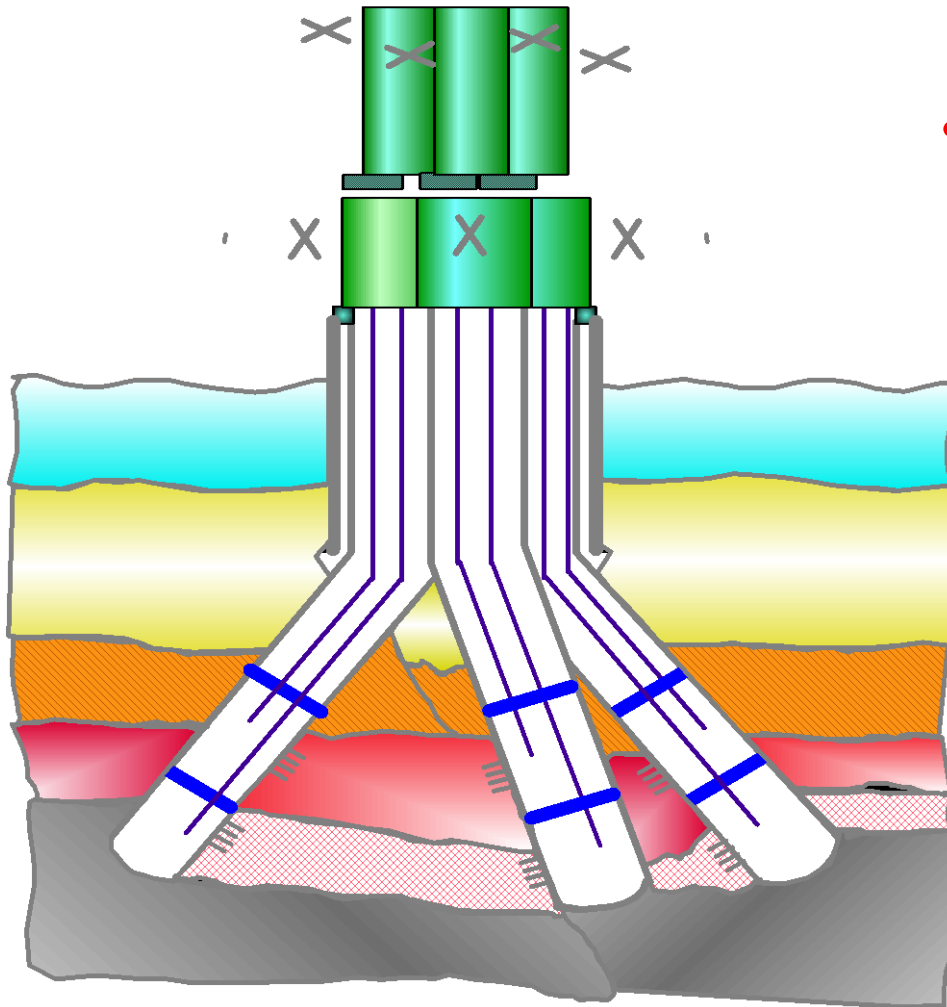


Triple Well Head



- The Triple Wellhead is now a proven technology
- It will make a marginal field economical to be developed
- It has the potential also to enhance project economics with installation of smaller platforms to drill the same number of wells

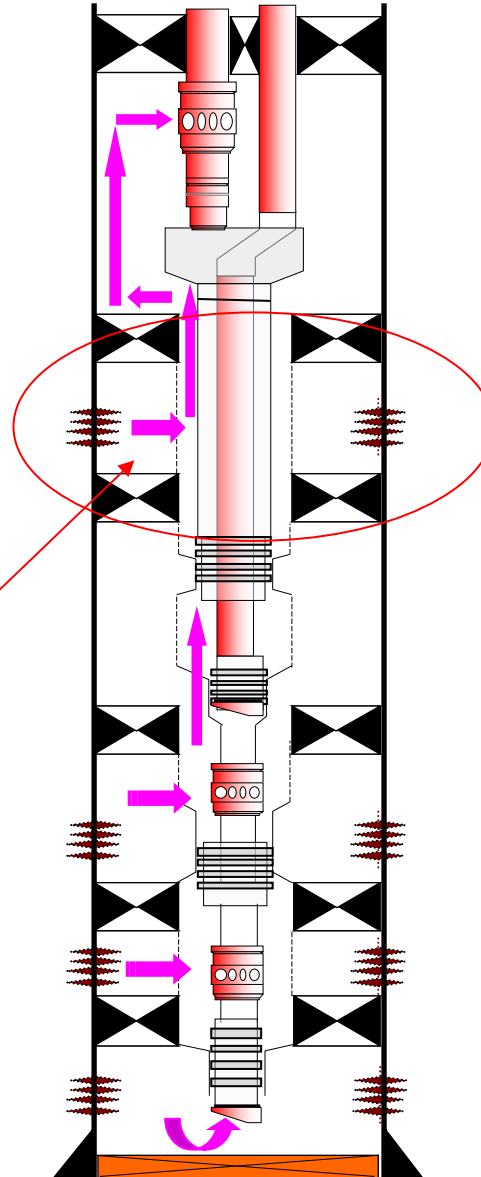
Triple well



- Three wells drilled and completed from one shared conductor

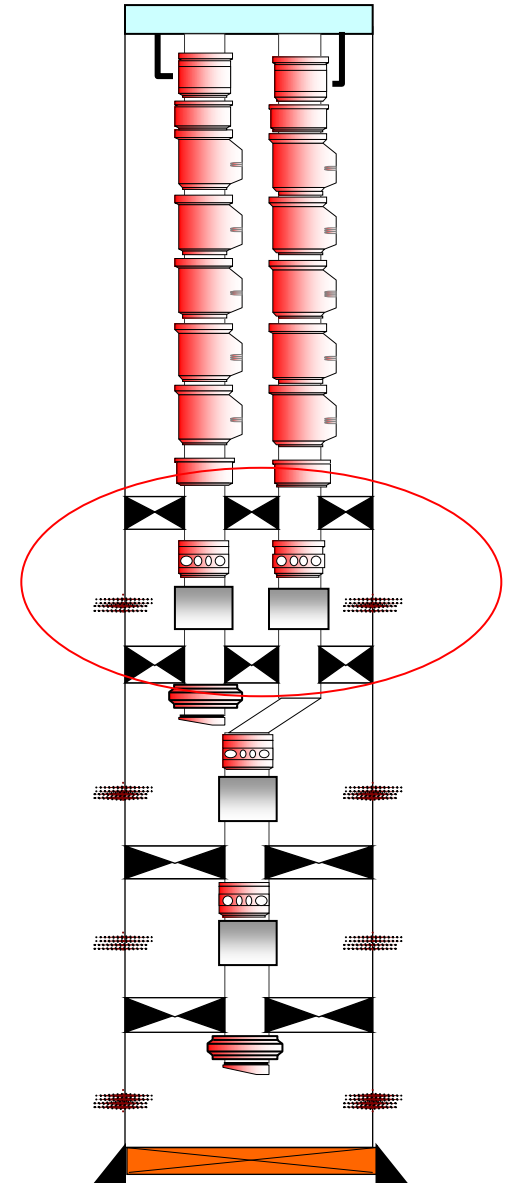
It provides 6 production strings

Y Block Completion

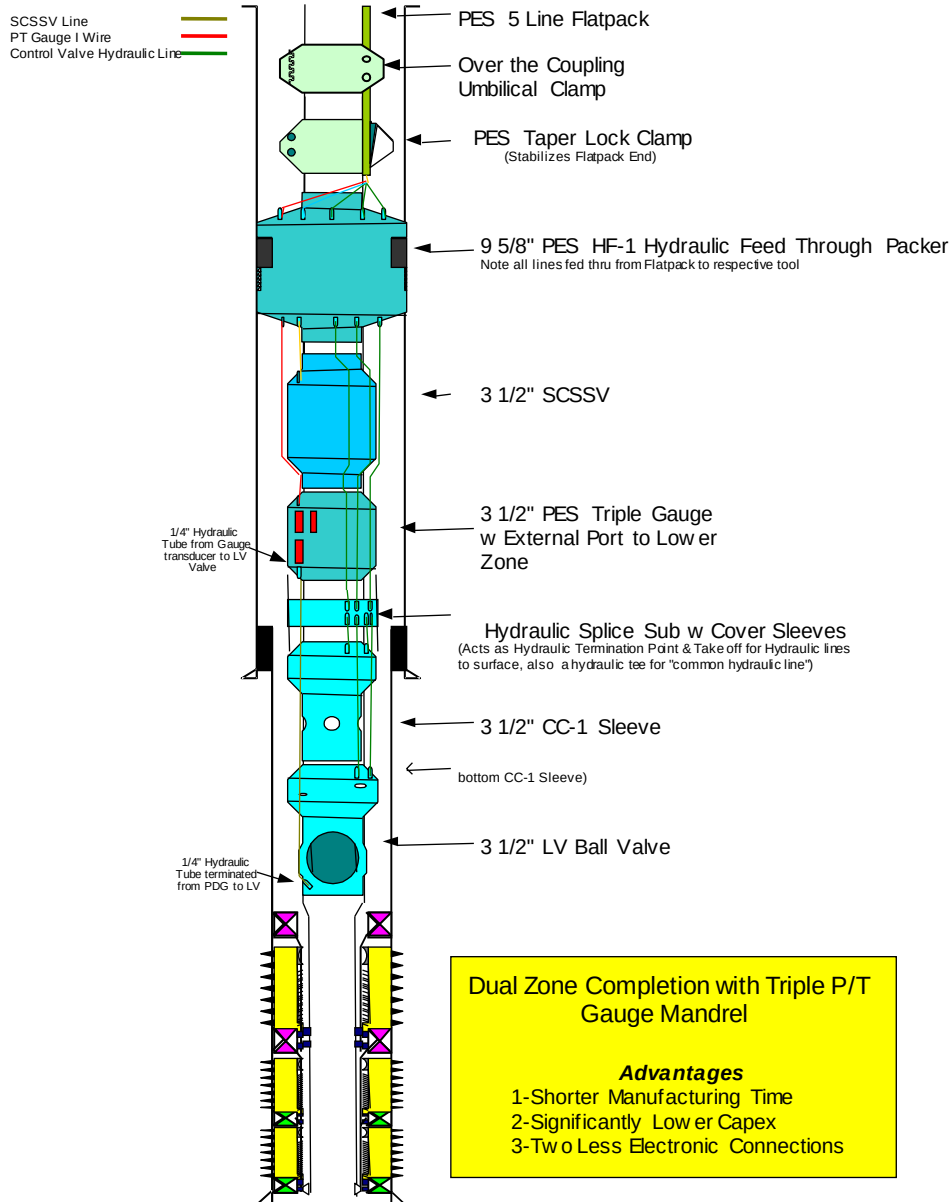


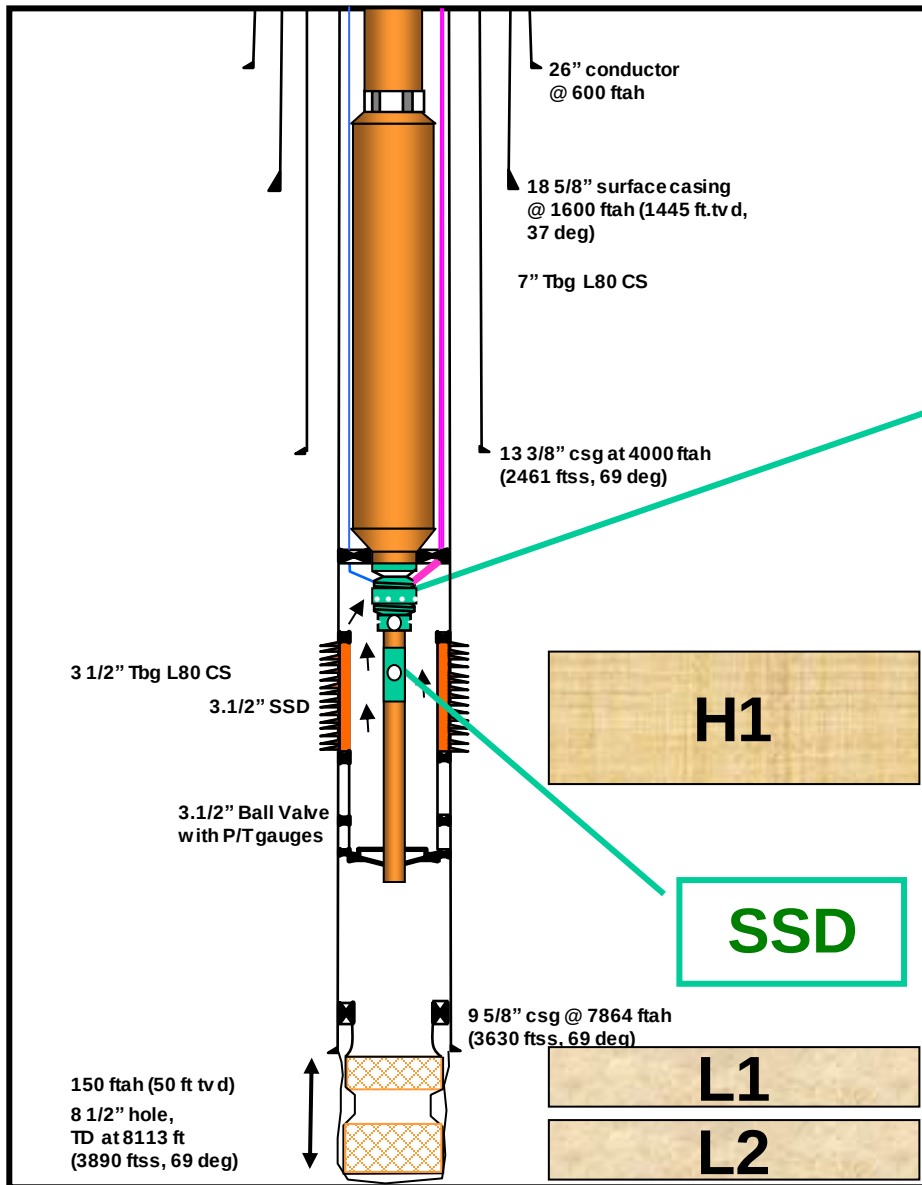
Without Y Block, selectivity on short string is not possible (for gravelpack completion).

Typical Dual string Completion



SMART well with downhole inflow control and P/T gauges



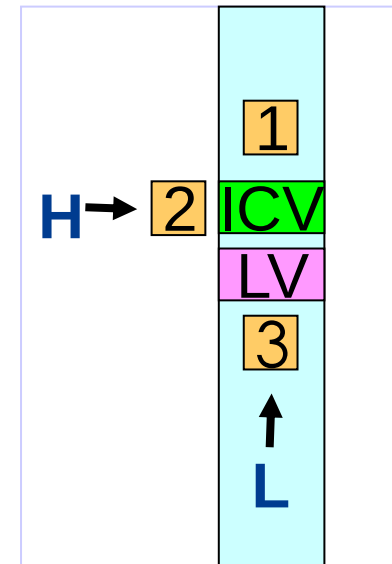


SMART

- Under Balanced Drilling
- SMART Commingling
- Expandable Sand Screen

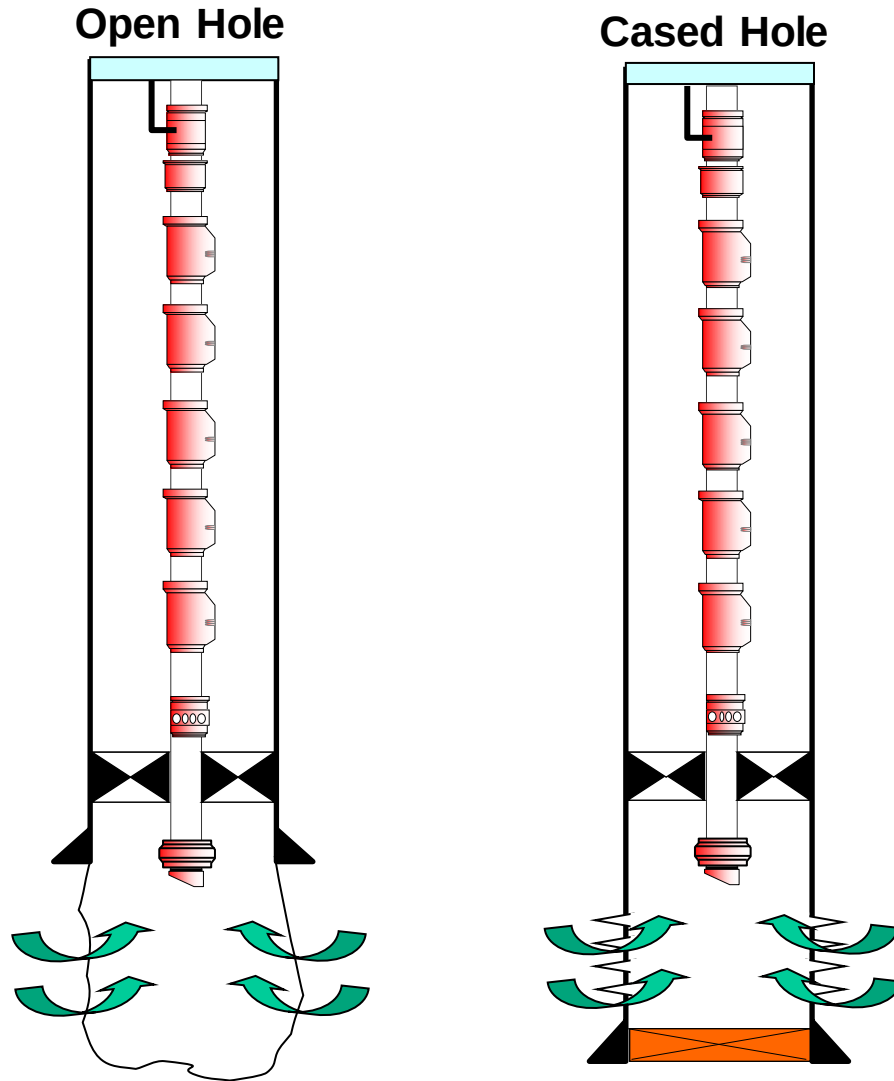
2 SMART VALVES

- Triple Gauge
- Interval Control Valve
- Lubricator Valve



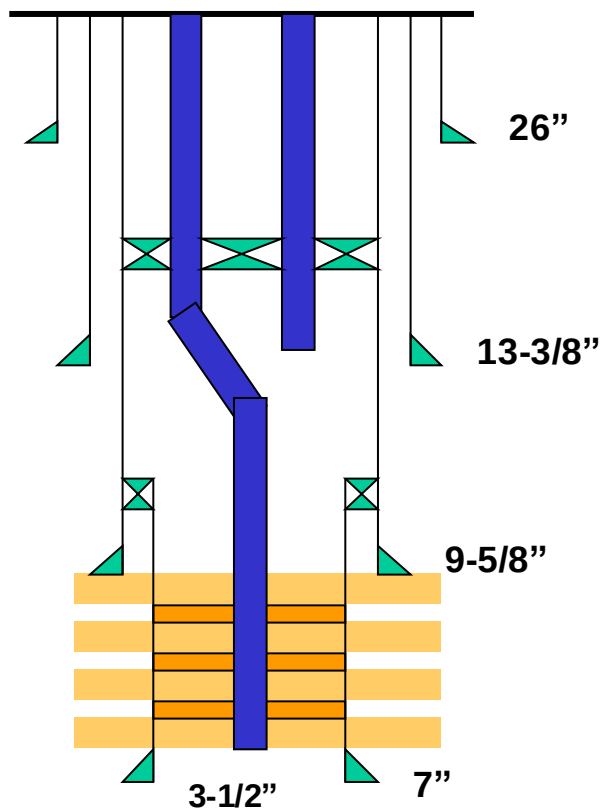
6. Methods of Well Completion

- Cased hole
- Open hole

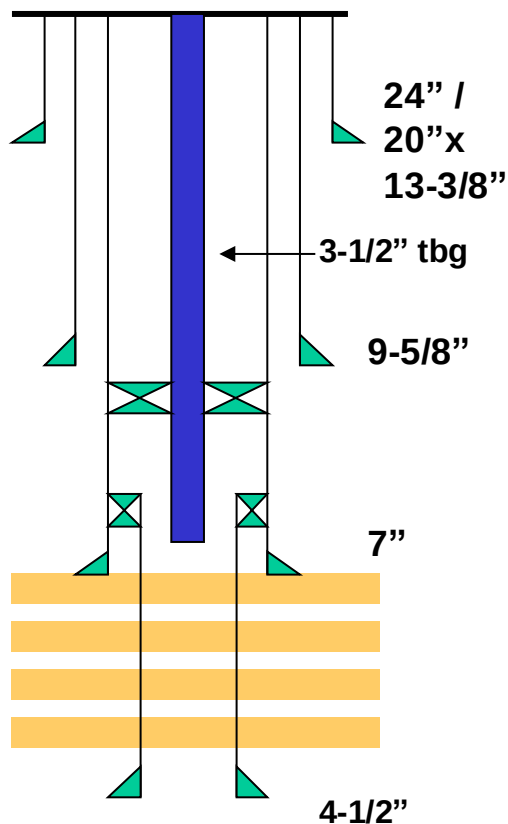


METHOD OF WELL COMPLETION

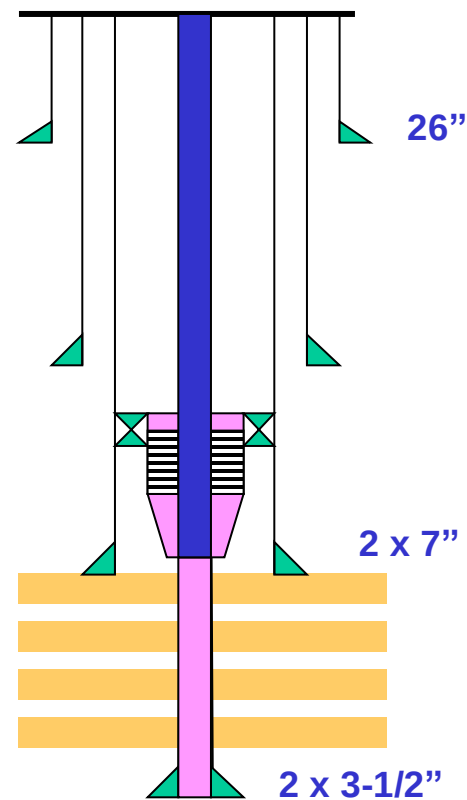
**Conventional
Single/dual**



**Slimhole
Single**



**Slimhole-
monobore**

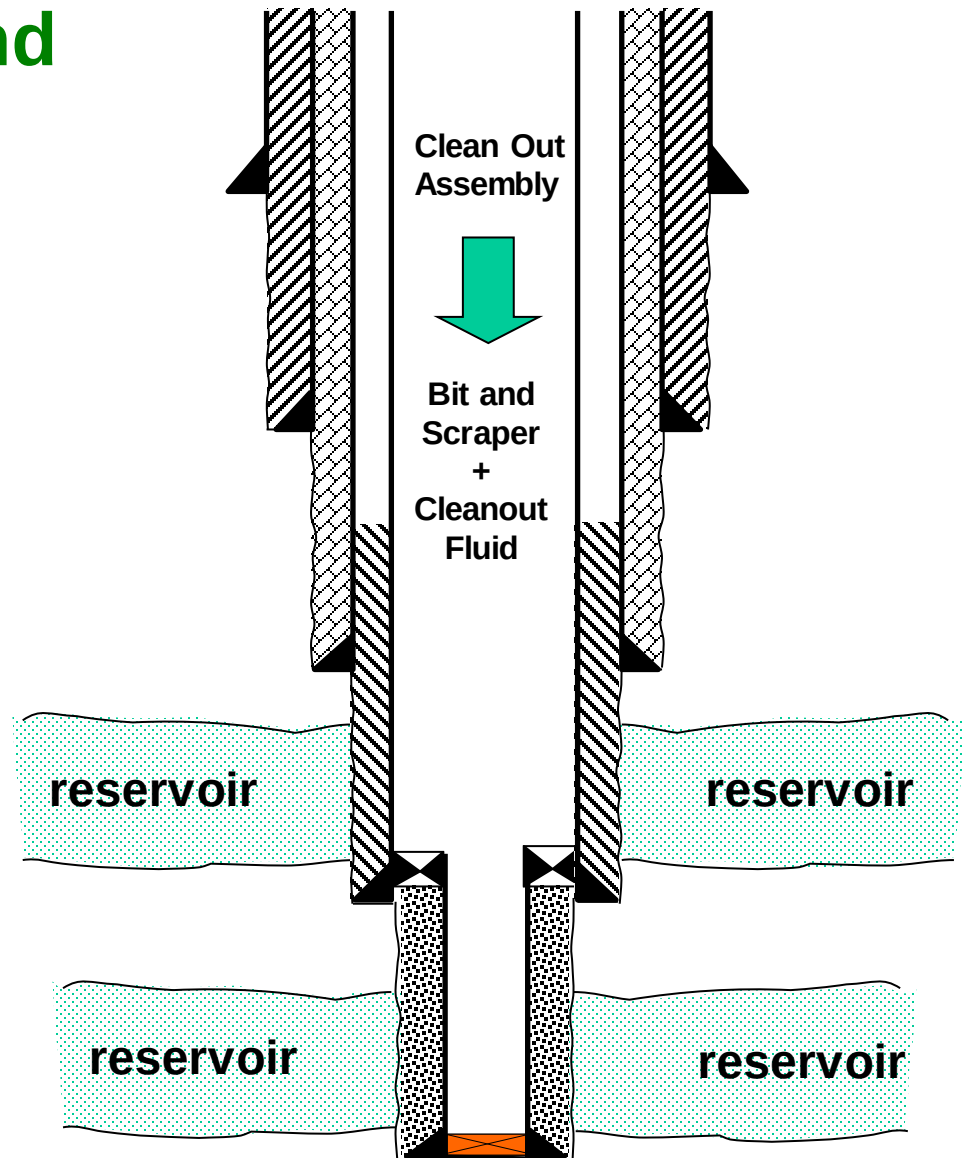


TD = 5450-8000 ft

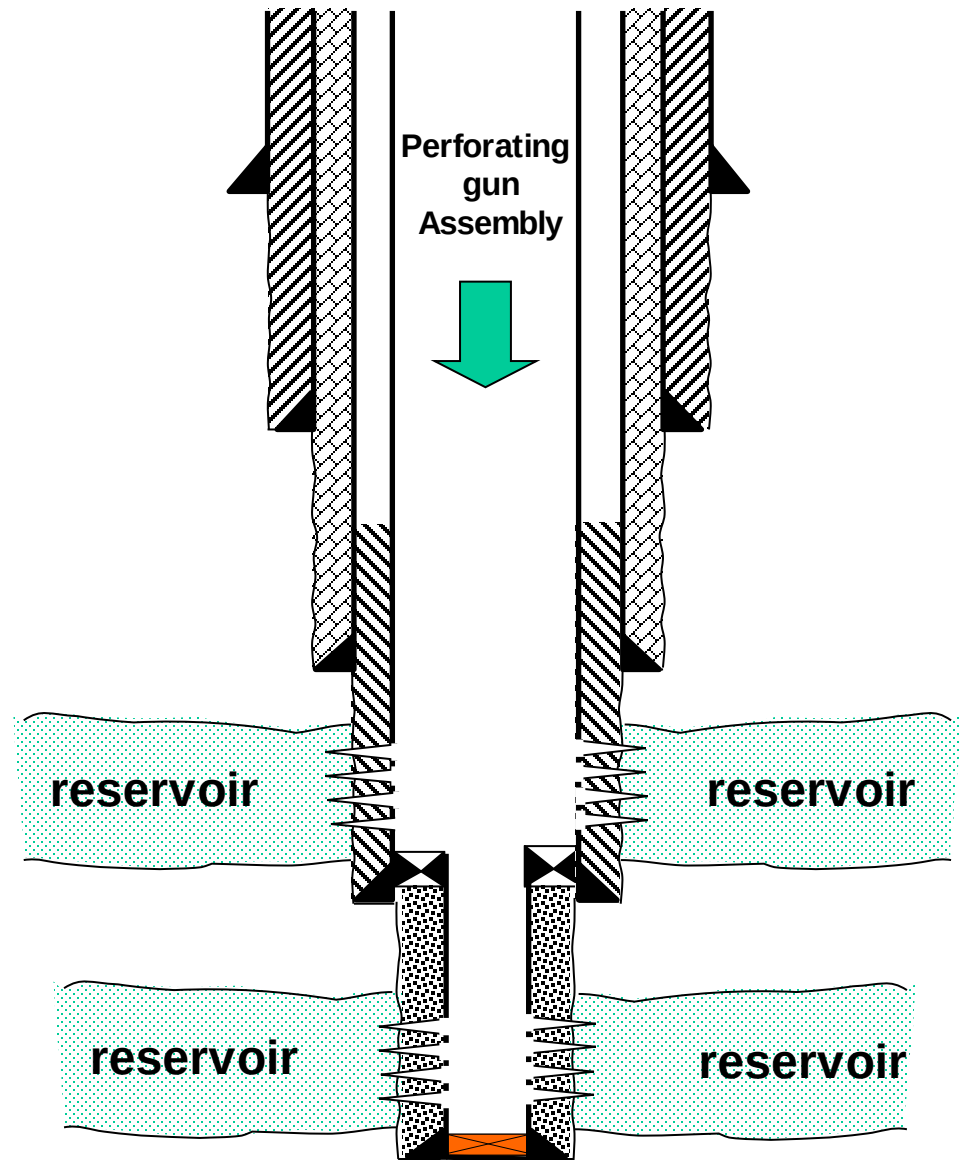
Sequence of Completion Operations :

- **Well cleanout**
- **Perforate**
- **Kill well**
- **(Sand exclusion - if required)**
- **Run and set completion string**
- **Install X-mas tree**
- **Flowline Tie-in**
- **Unloading well**
- **Handover to production**

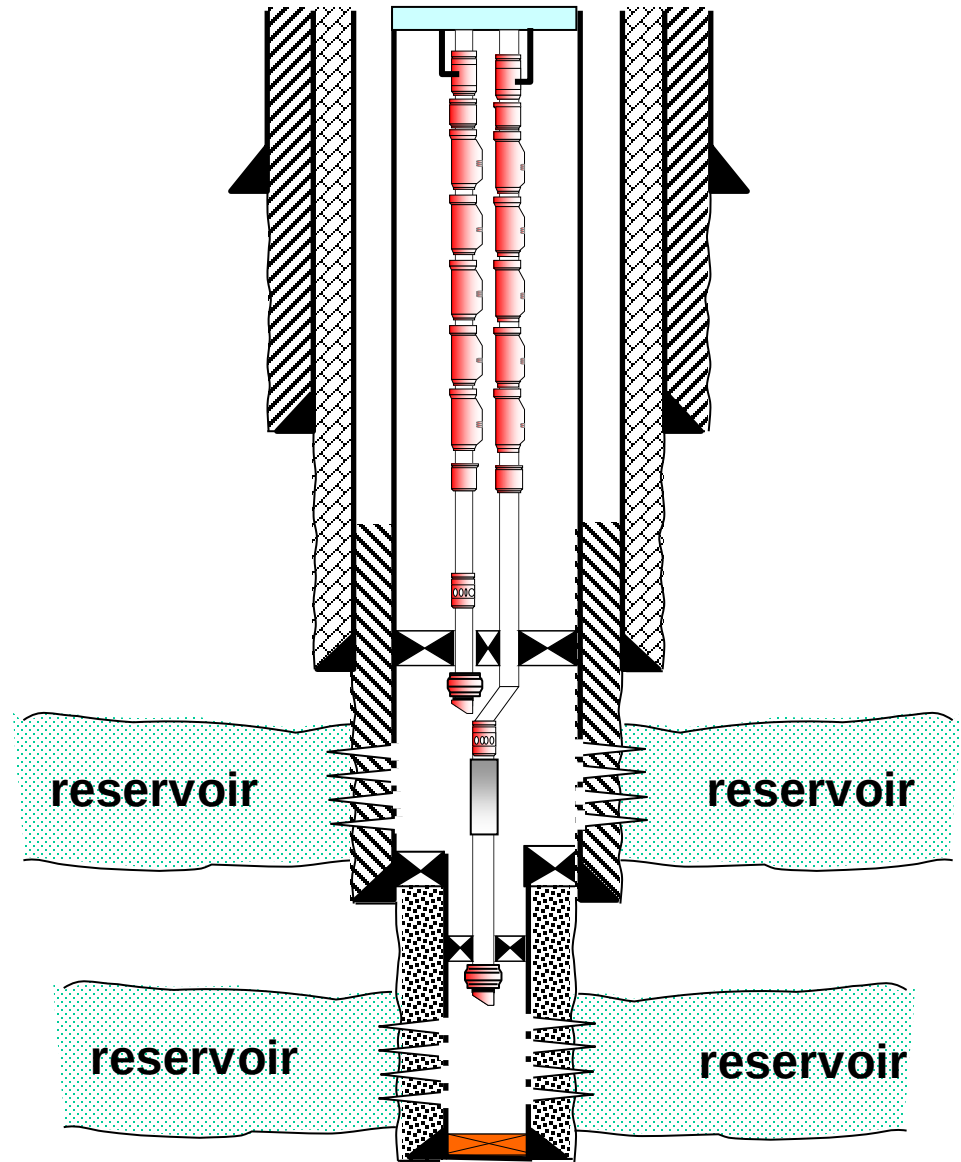
Well Preparation And Cleaning



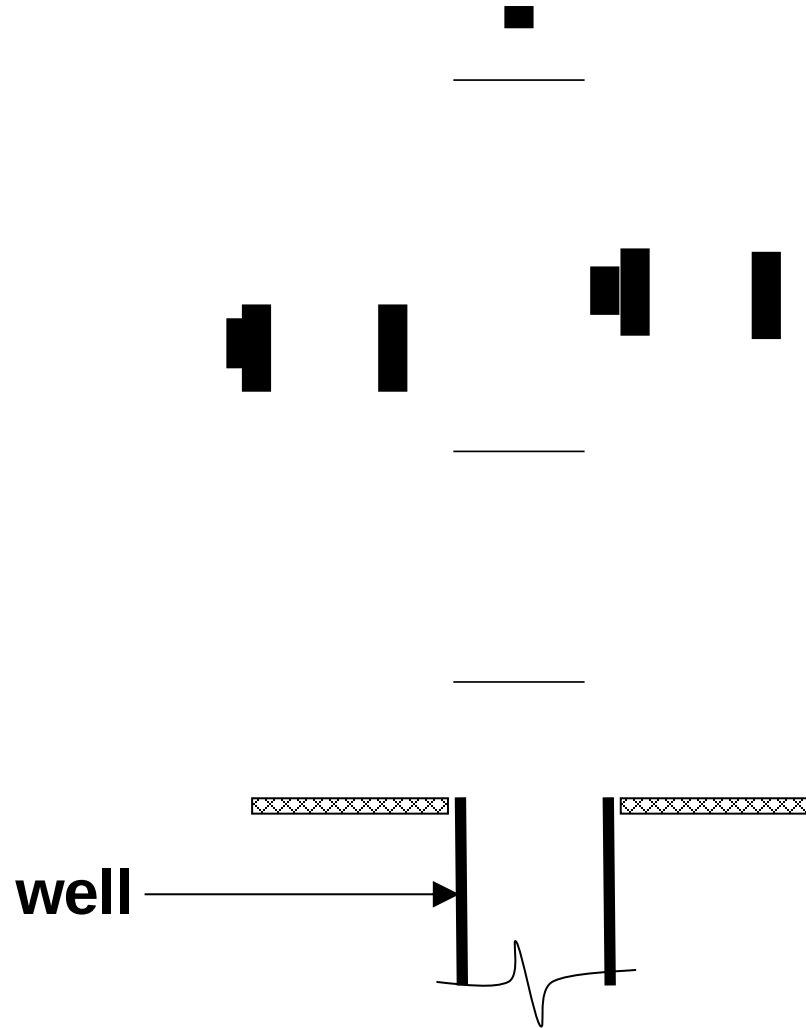
Well Perforating



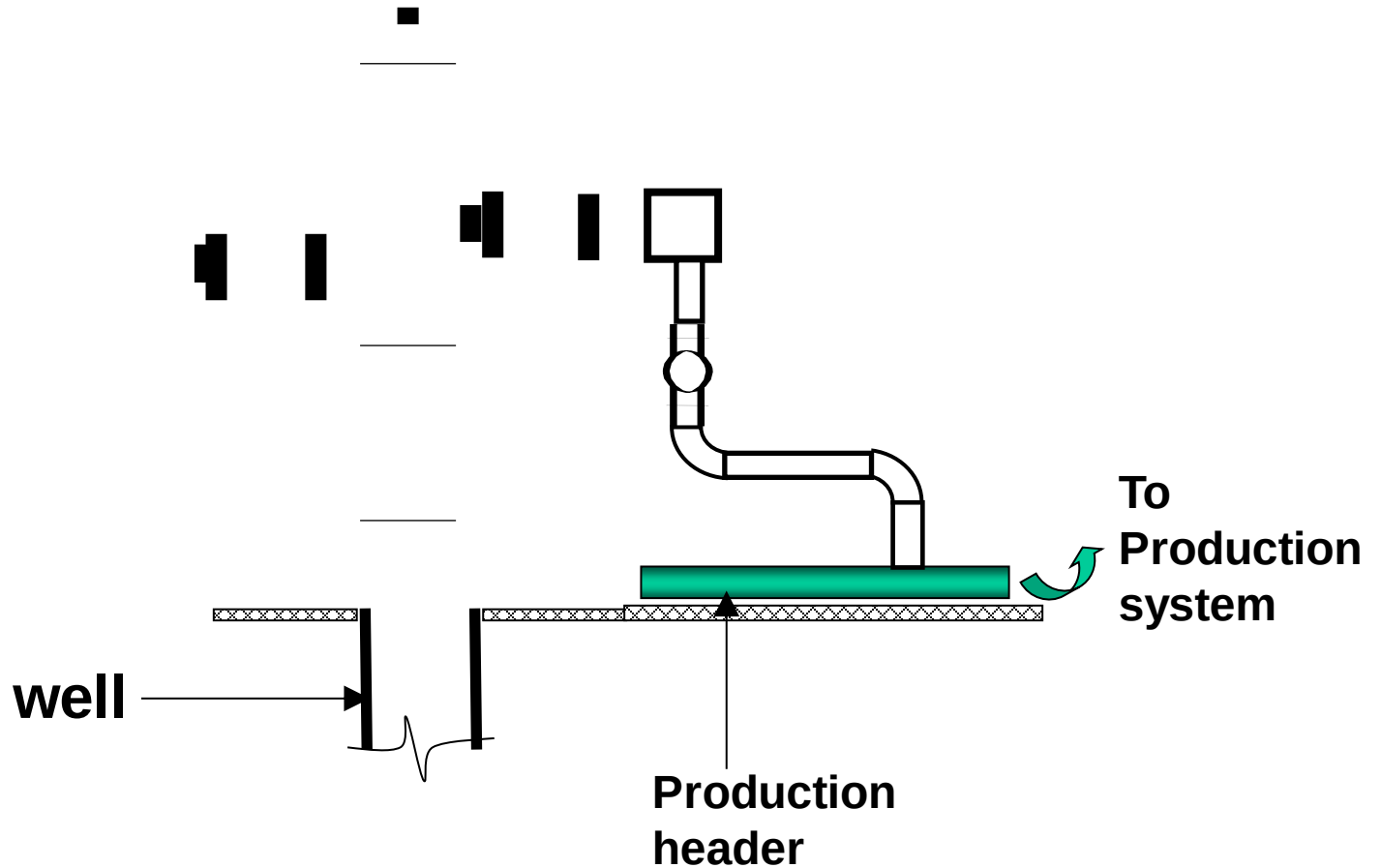
Running Completion

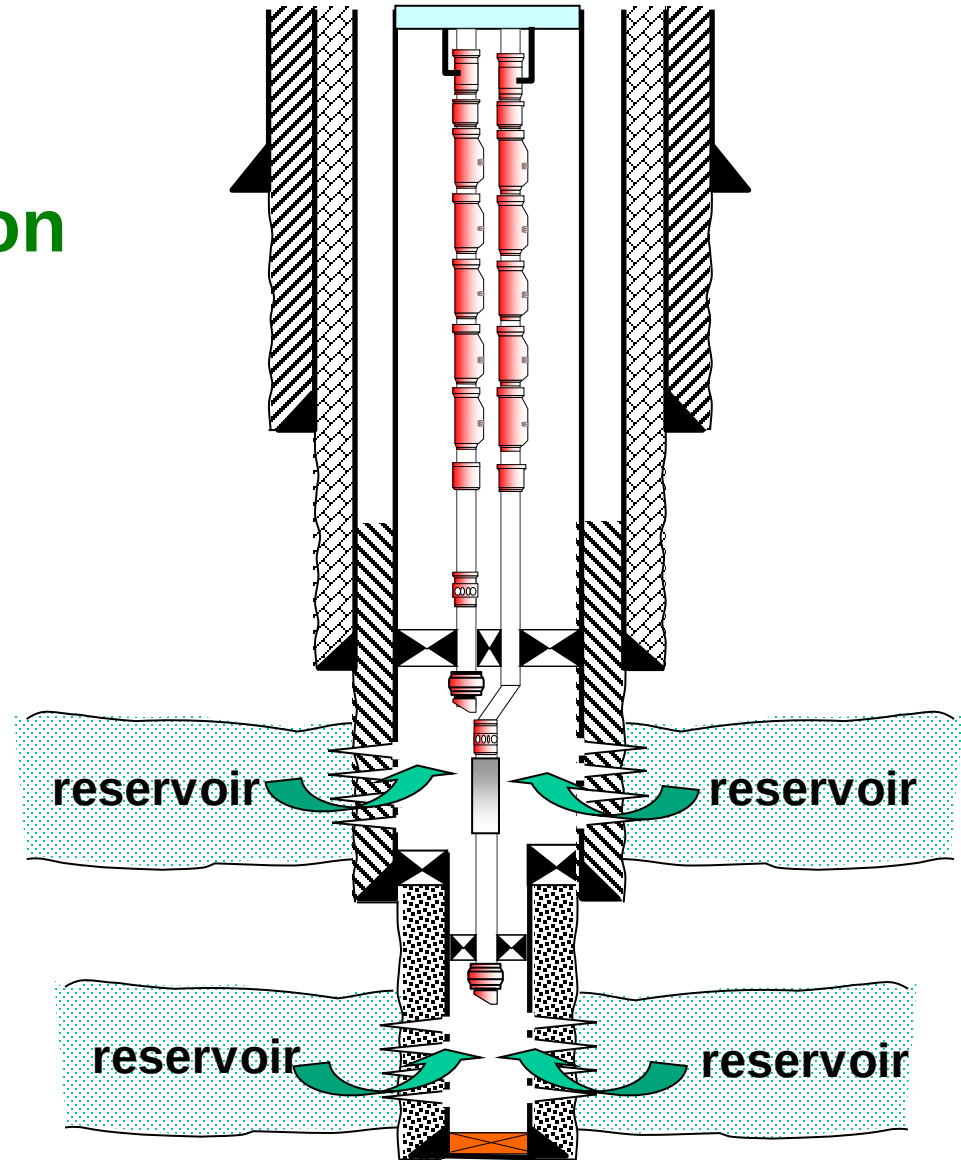


Install Christmas Tree



Production Flow Line Tie-In





7. Mechanical Considerations

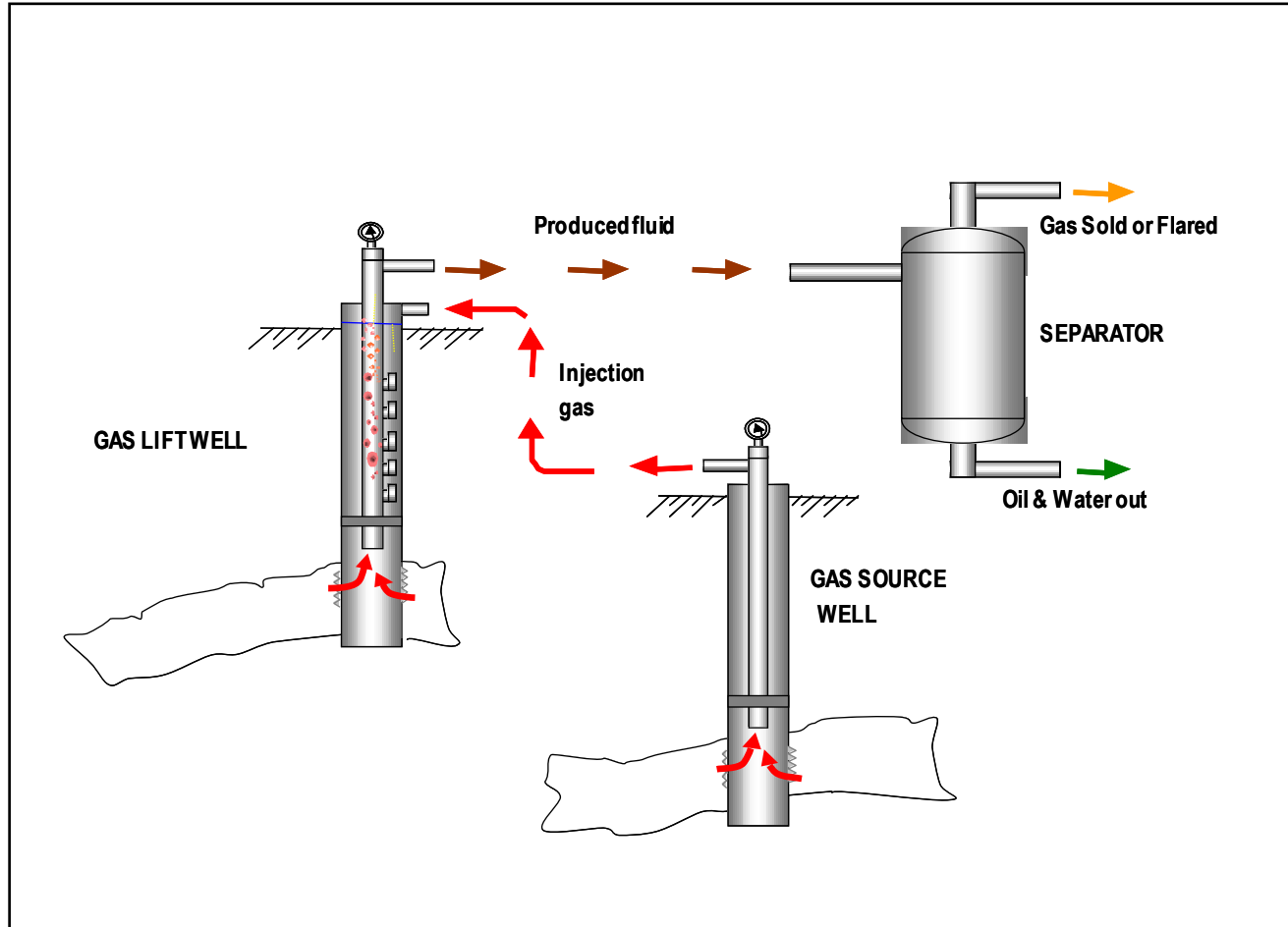
- **Safety**
- **Simplicity/Reliability**
- **Well Surveillance/Monitoring Requirement**
- **Tubing Stress and Movement**
- **Future Slick/E-line Intervention Technology**
- **Future Work-over and Abandonment.**

There are different ways of completing wells with different types of artificial lift

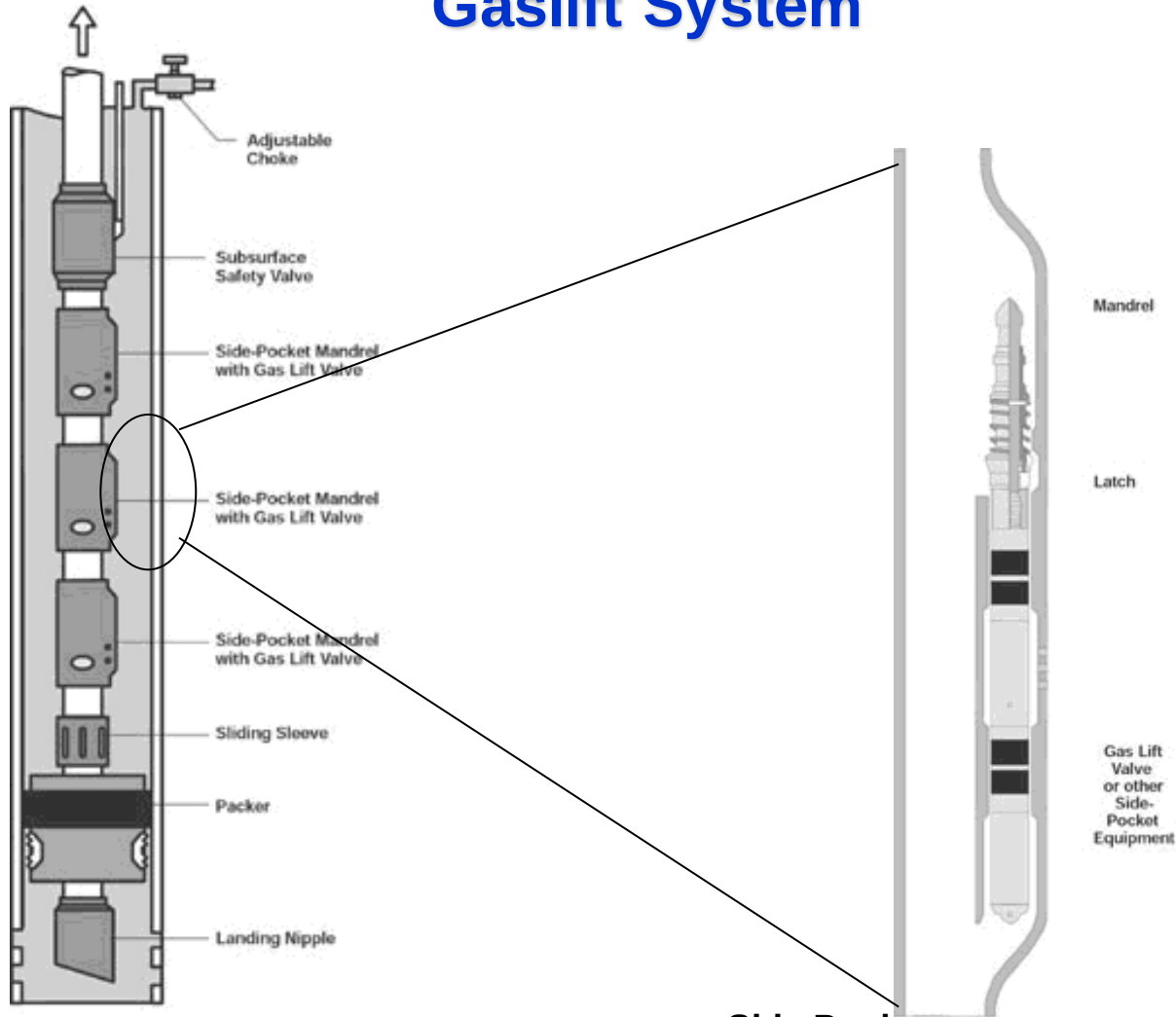
Types of artificial lift :

- Gas lift
- Sucker rod (Bean Pump)
- Progressing Cavity Pump (PCP)
- Electrical Submersible Pump (ESP)
- Subsurface Hydraulic Jet Pump (SHJP)
- Plunger Lift

Artificial lift – Gaslifting Well



Artificial Lift Gaslift System

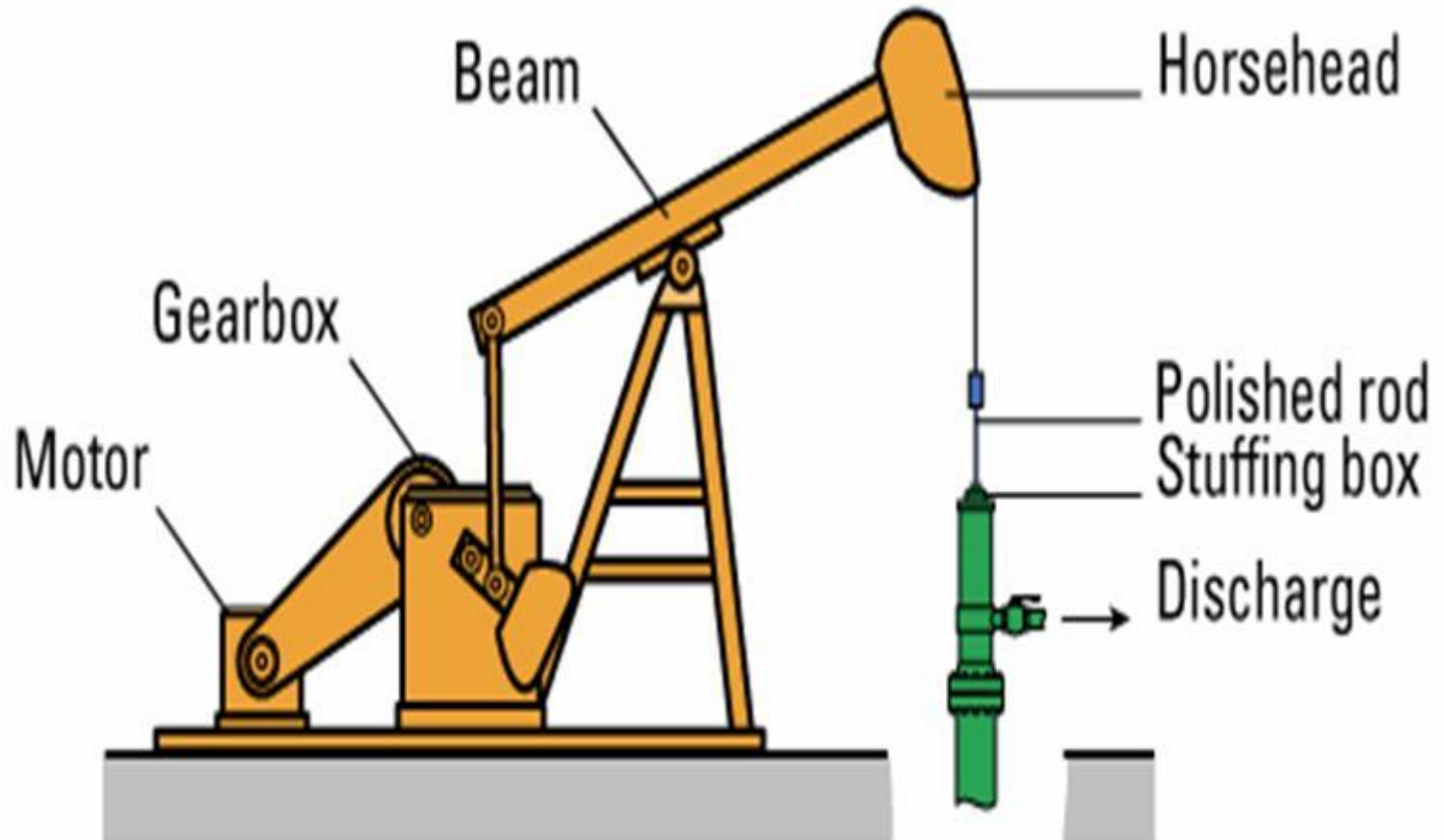


**Gas-Lift Completion—SPMs
and Retrievable Valves**

**Side Pocket Mandrel with
Gas-Lift Valve**

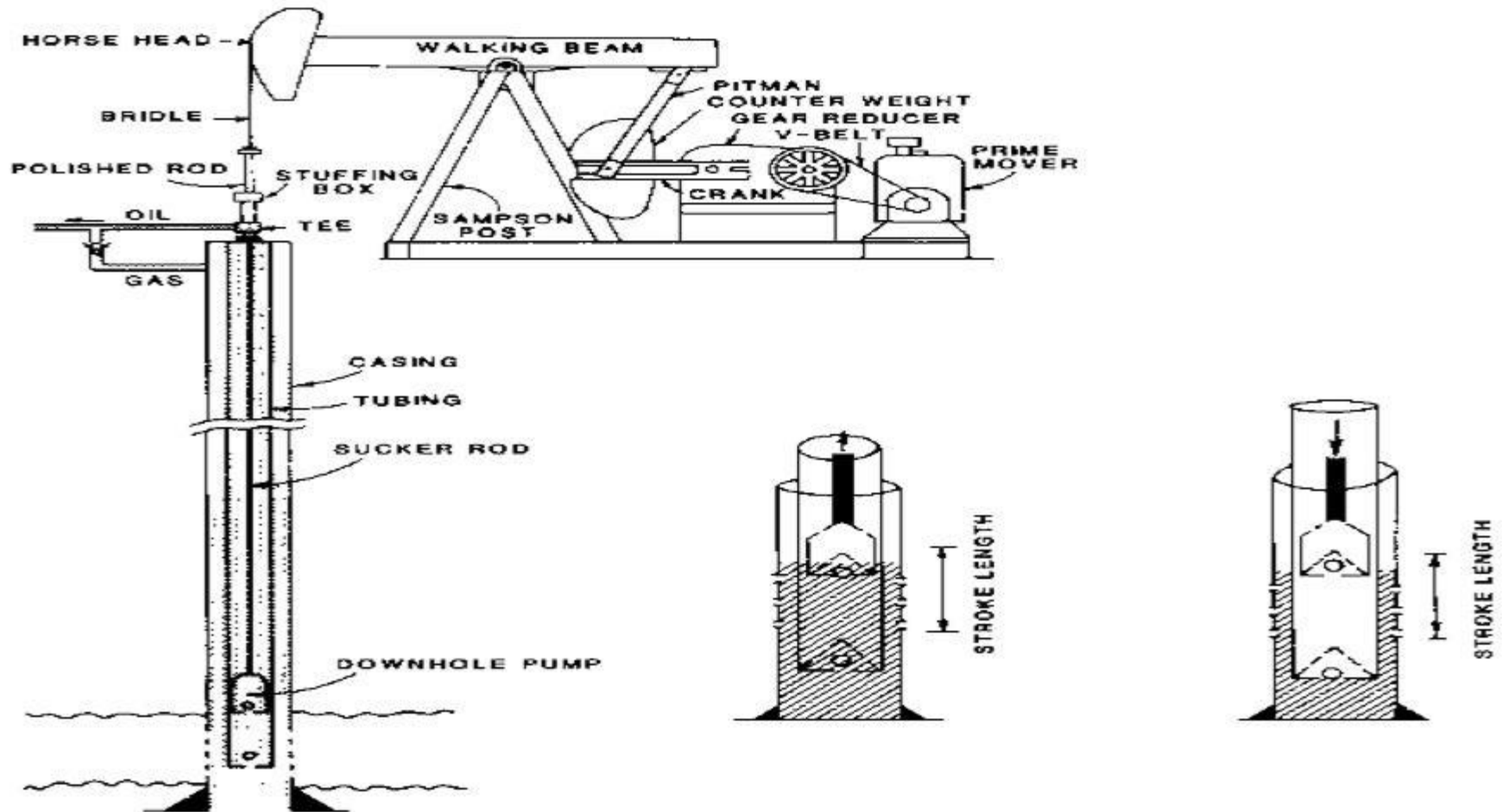
Artificial Lift

Sucker rod (Bean Pump)



Artificial Lift

Sucker Rod Pump (SRP)



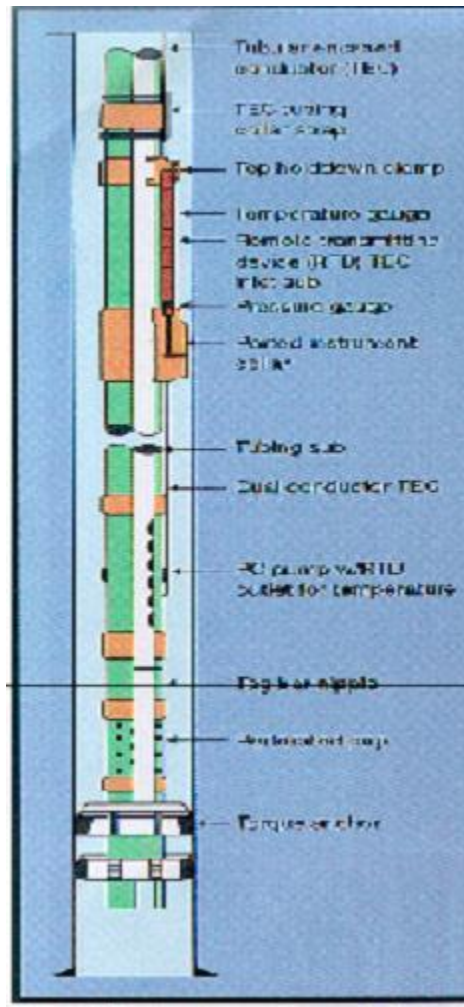
Artificial Lift

Progressing Cavity Pump (PCP)

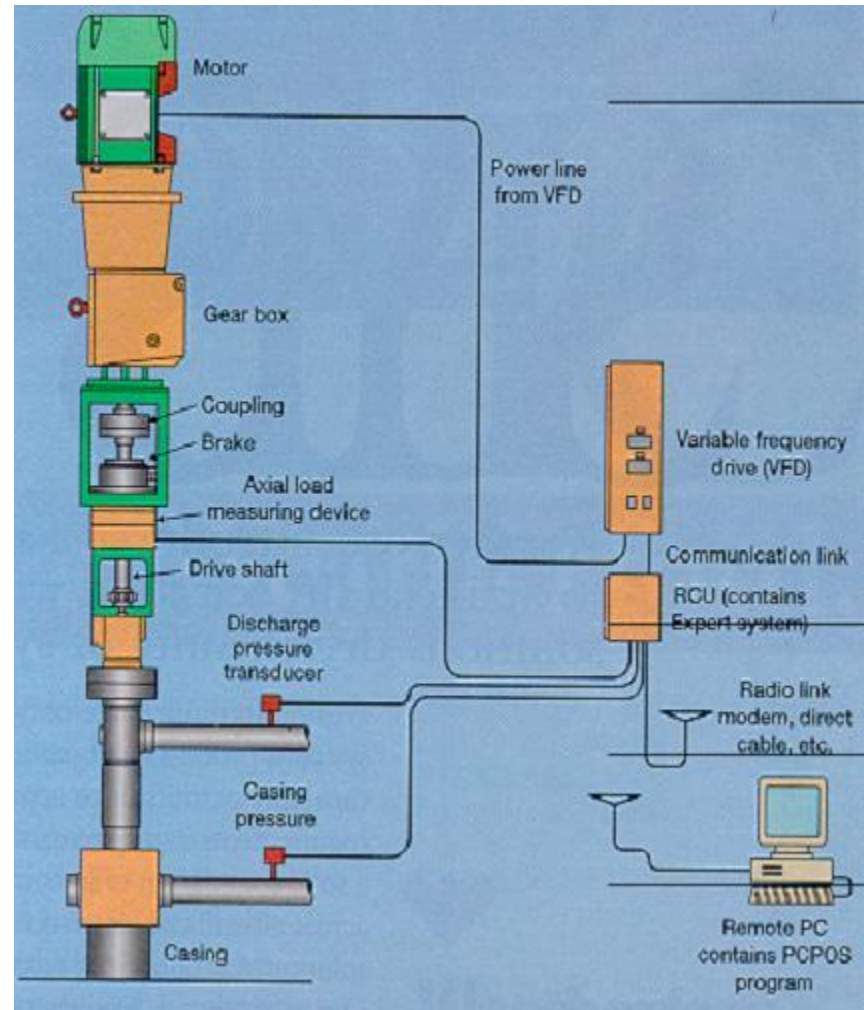


Artificial Lift

Progressive Cavity Pump (PCP)



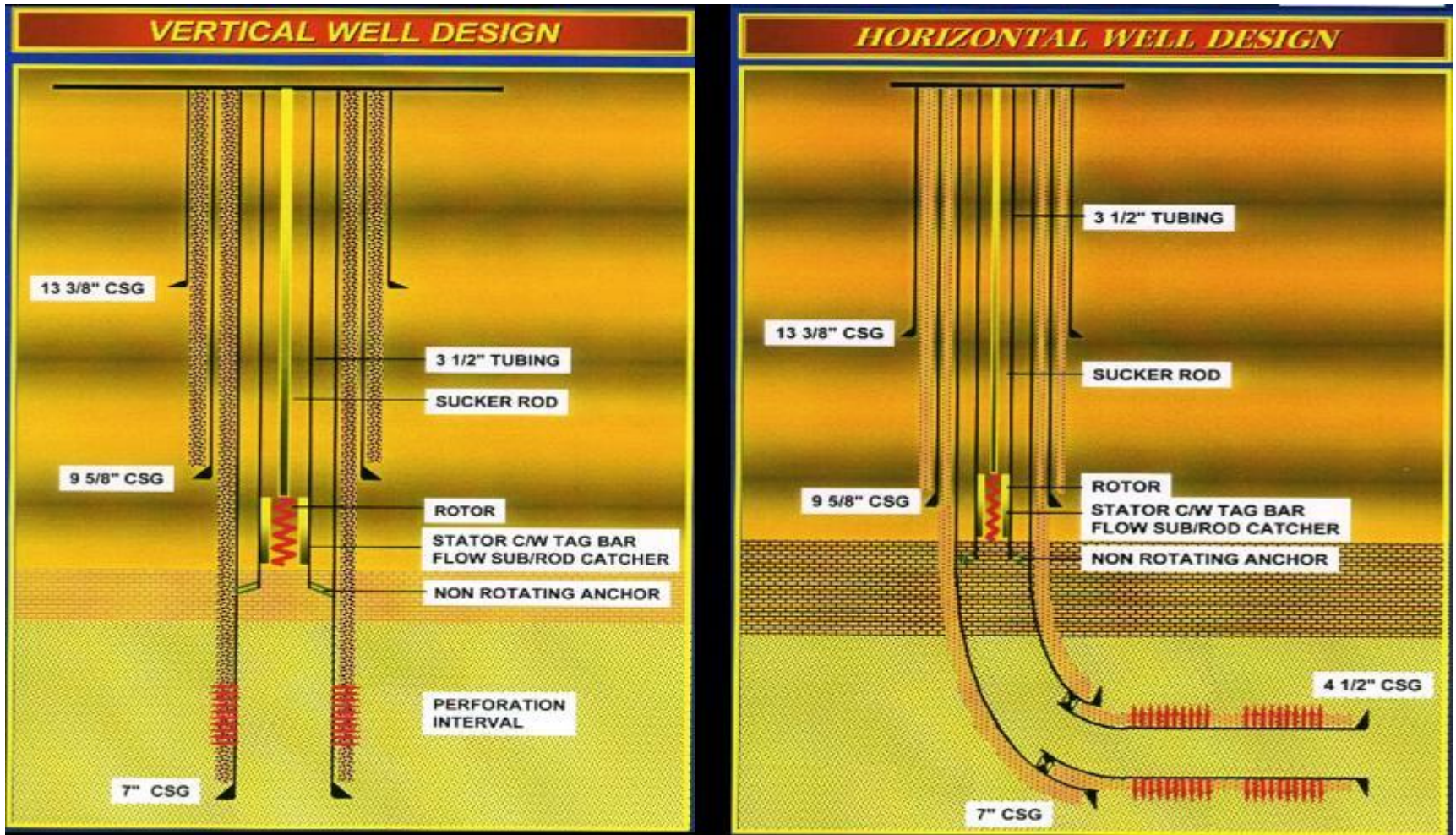
PCP Down Hole Equipment



PCP Surface Facilities

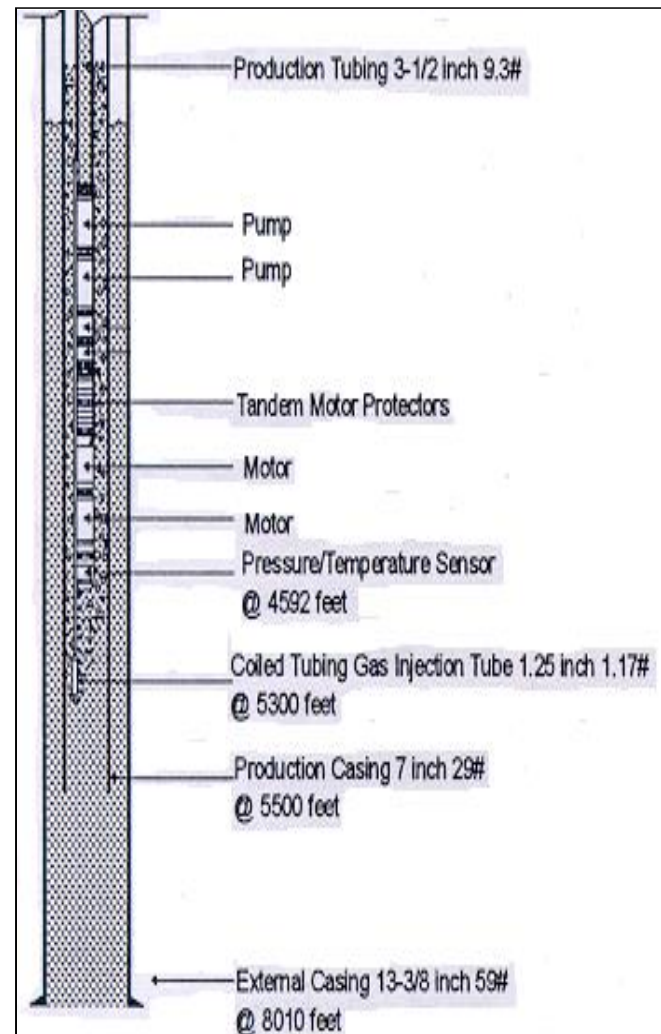
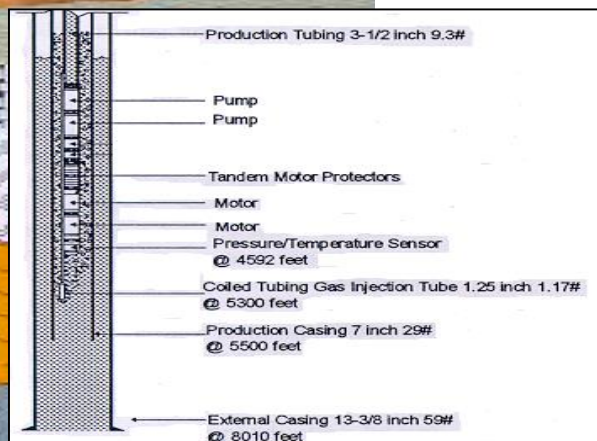
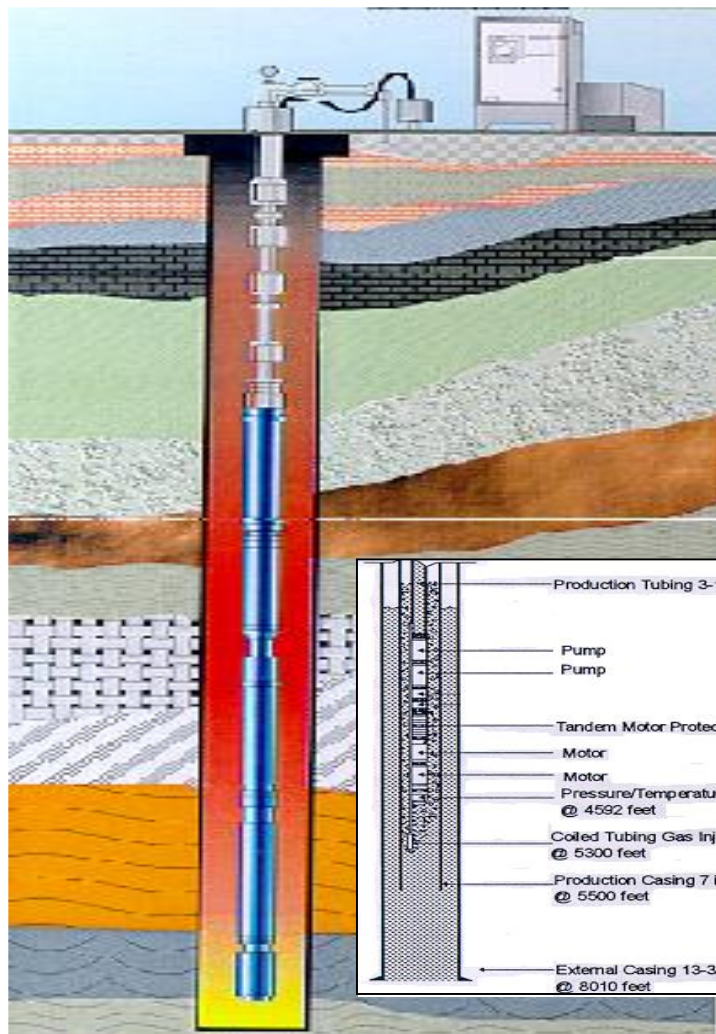
Artificial Lift

Progressive Cavity Pump (PCP)

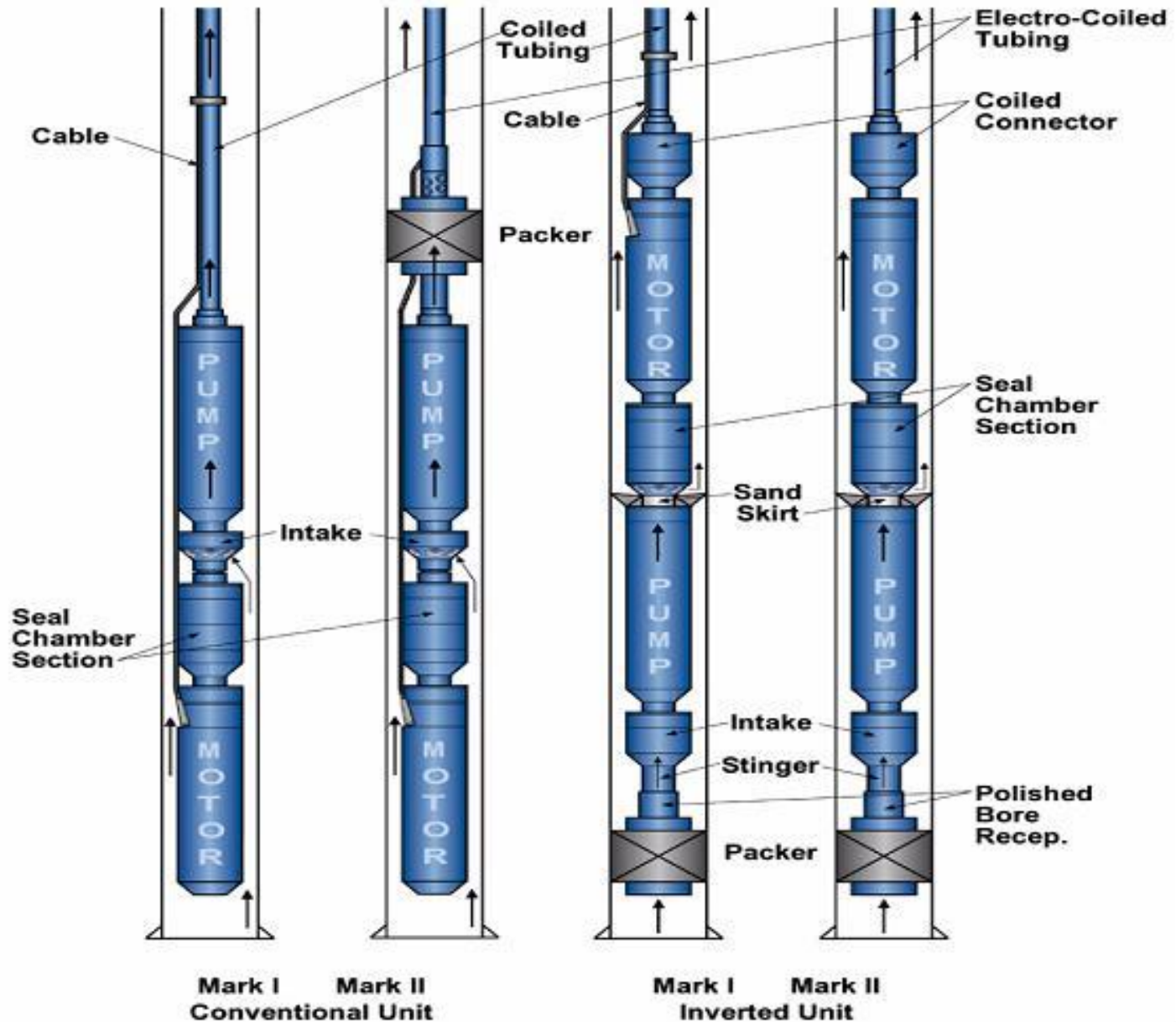


Artificial Lift

Electrical Submersible Pump (ESP)

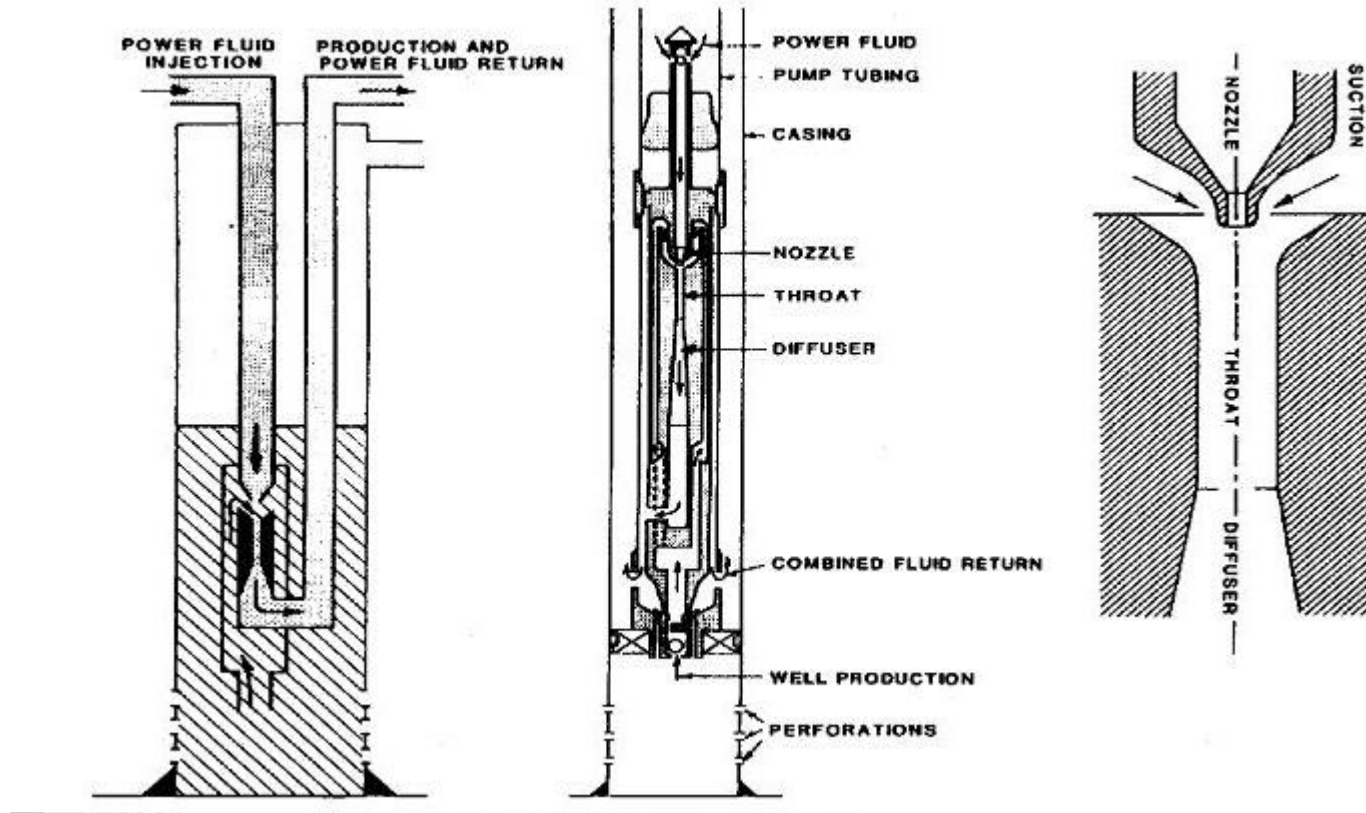


Artificial Lift

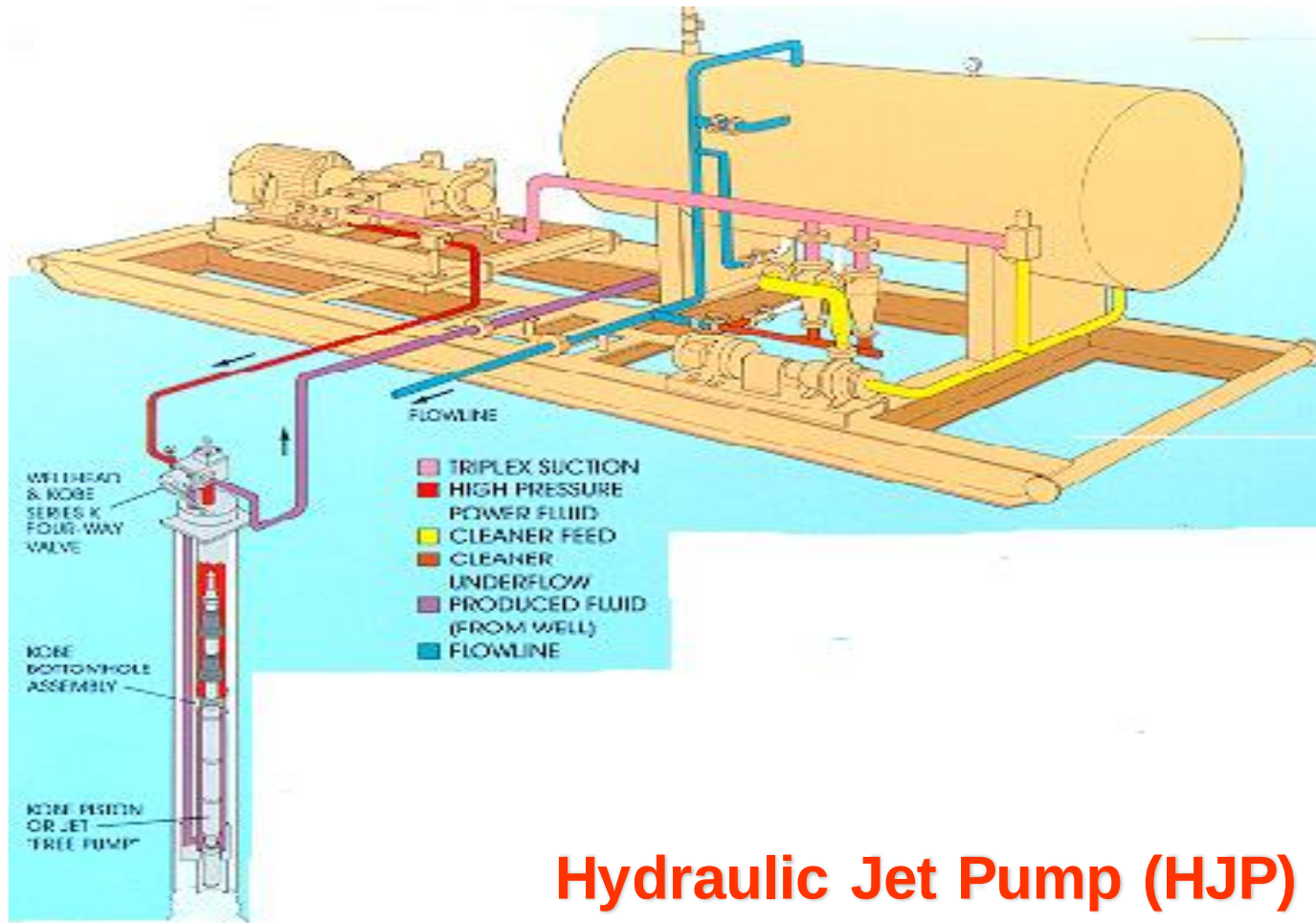


Artificial Lift

Hydraulic Jet Pump (HJP)



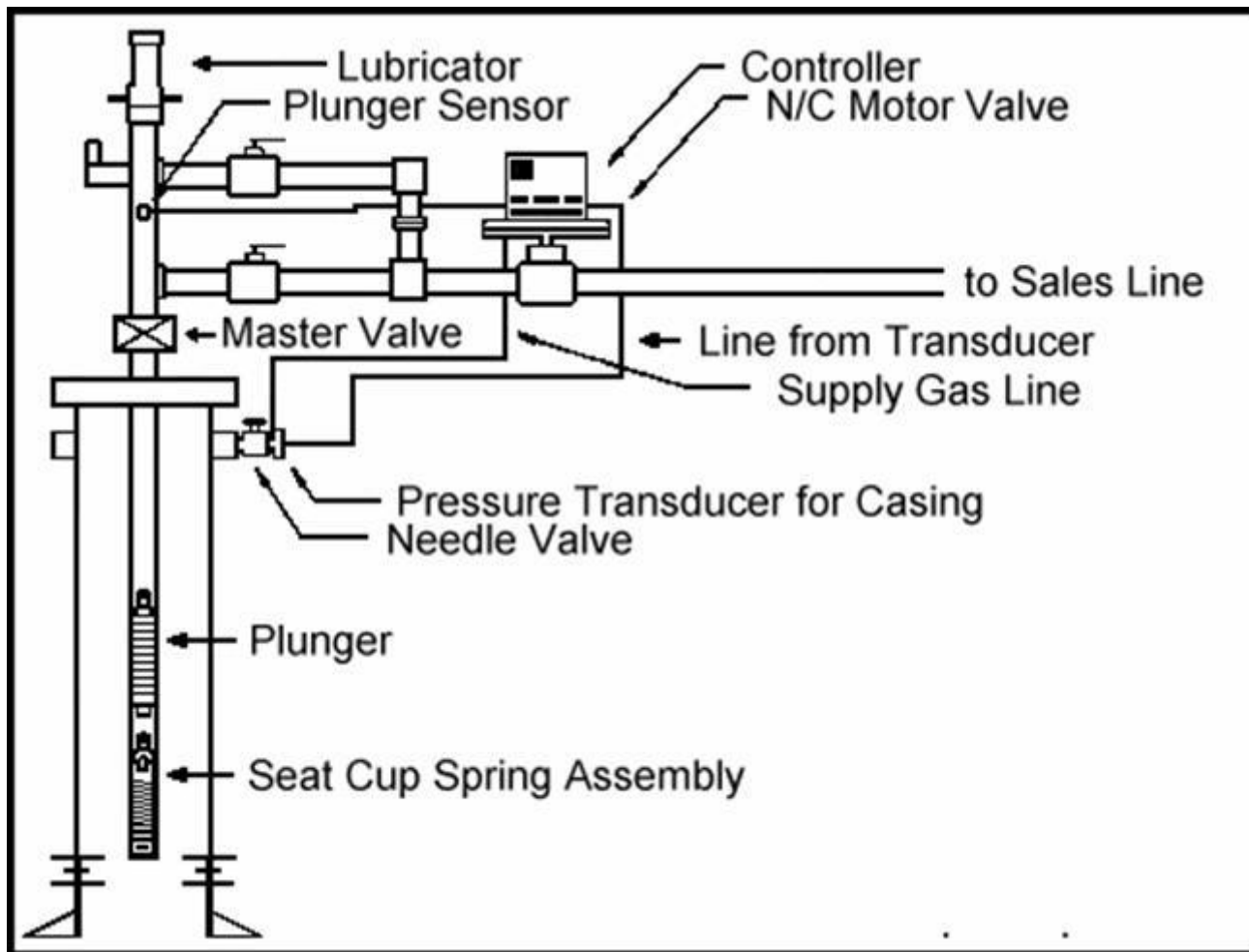
Artificial Lift



Hydraulic Jet Pump (HJP)

Artificial Lift

Plunger Lift



THANK YOU

PCSB's well completion review

- Most of PCSB's wells are cased hole either single or dual completion. However, there are a few wells completed opened hole (slotted liner).
- Tubing size used range from 2-3/8" to 5-1/2 OD.
- PCSB has completed horizontal wells, multilateral wells, wells with gravel packing completion, slim well and one twin well.
- Completion with 1 packer to 6 packers, completing from 1 to 5 zones in a single wellbore.