Performance of Flowing Wells

By

Matthew Amao

Lecture Outline

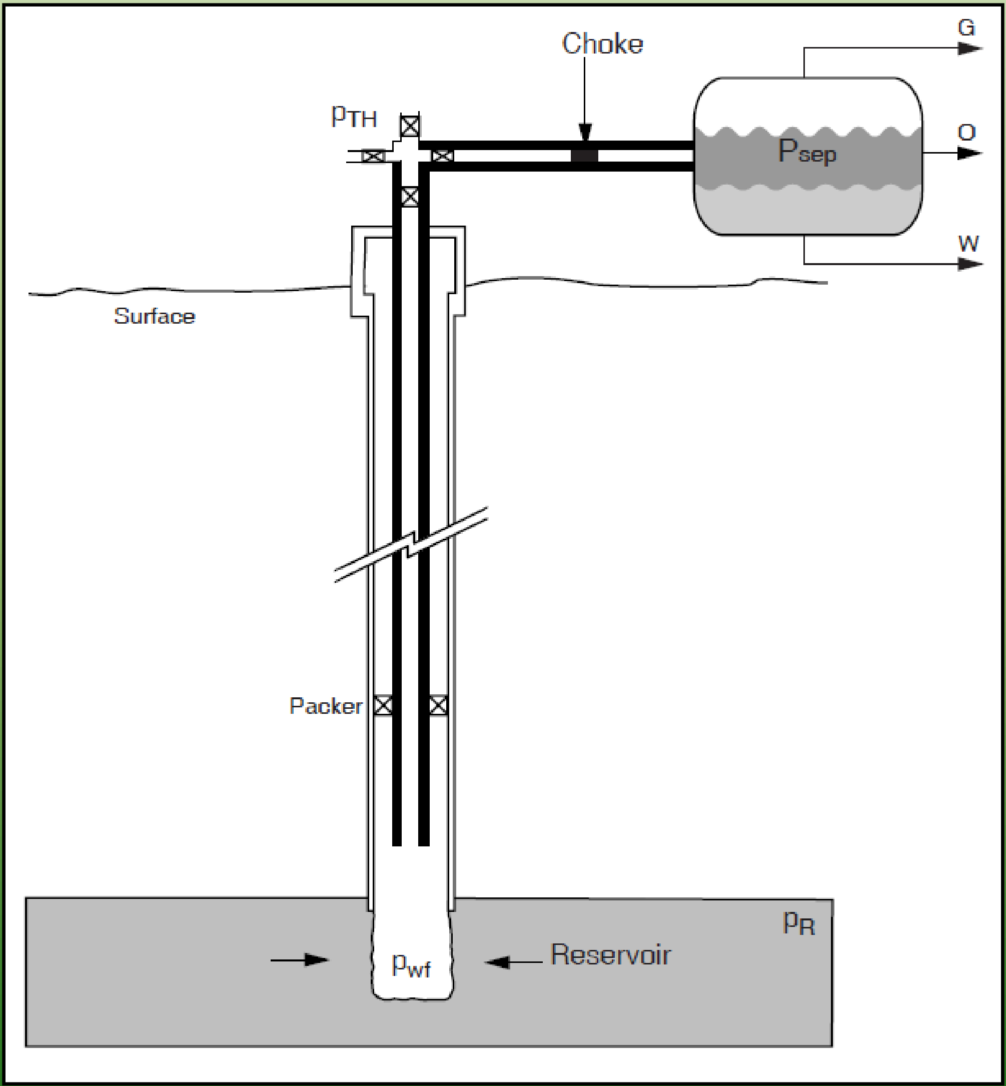
- Introduction
- Inflow Performance Relationship (IPR)
- Vertical Lift Performance (VLP)
- Choke Performance
- Well Deliverability
- Summary
- References

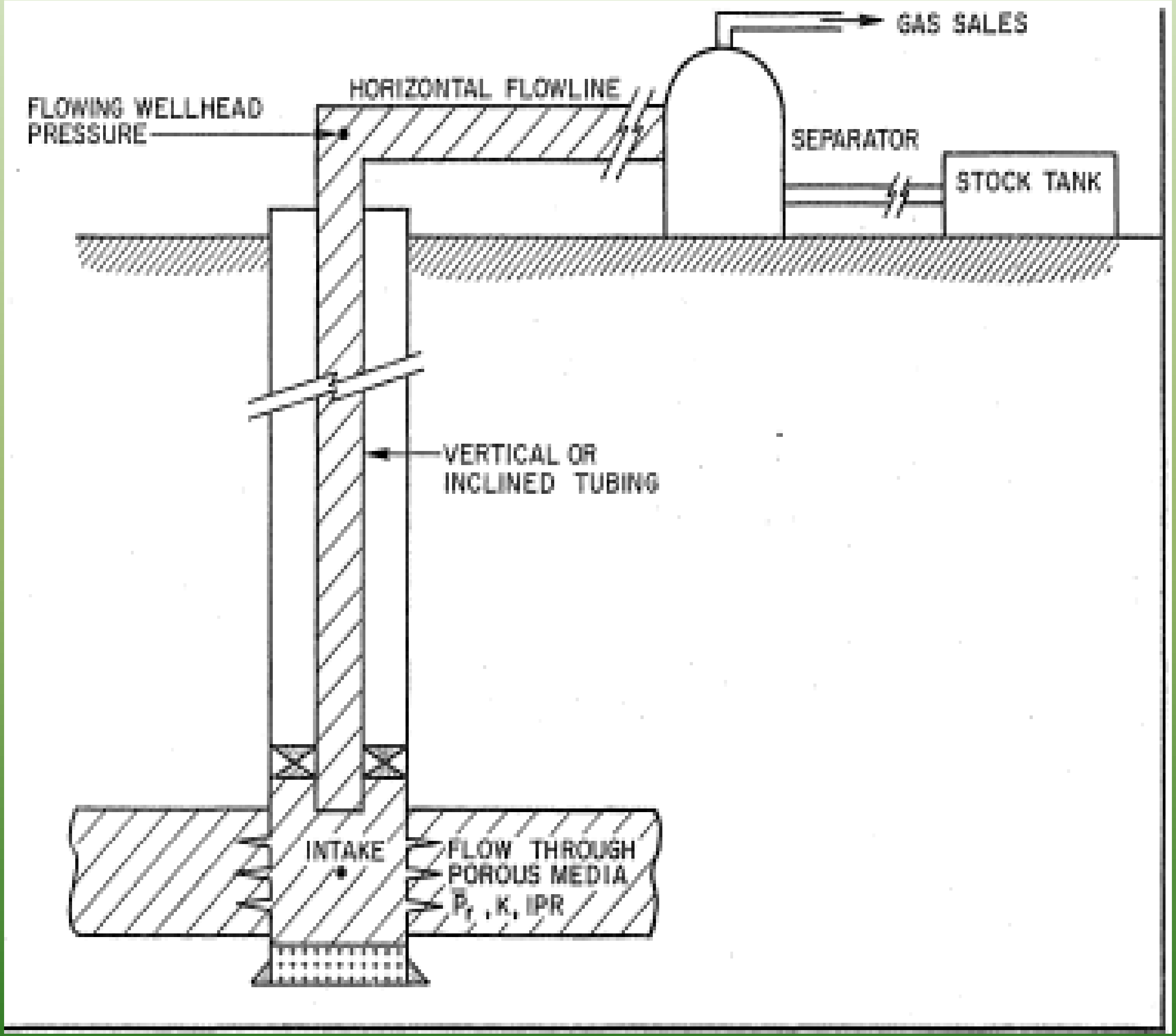
Introduction
Well Productivity

The productivity of the well depends on an efficient use of the compressional energy available in the reservoir and reservoir fluids. The design of the production system must efficiently utilize this energy.

Pressure loss in the system which leads to dissipation of reservoir energy occurs at;

- The Reservoir
- The wellbore
- The Tubing String
- The Choke
- The Flow line
- The Separator




GAS SALES
HORIZONTAL FLOWLINE
FLOWING WELLHEAD
PRESSURE
SEPARATOR
STOCK TANK
VERTICAL OR
INCLINED TUBING
INTAKE
FLOW THROUGH
POROUS MEDIA
$\bar{P}_r$, K, IPR

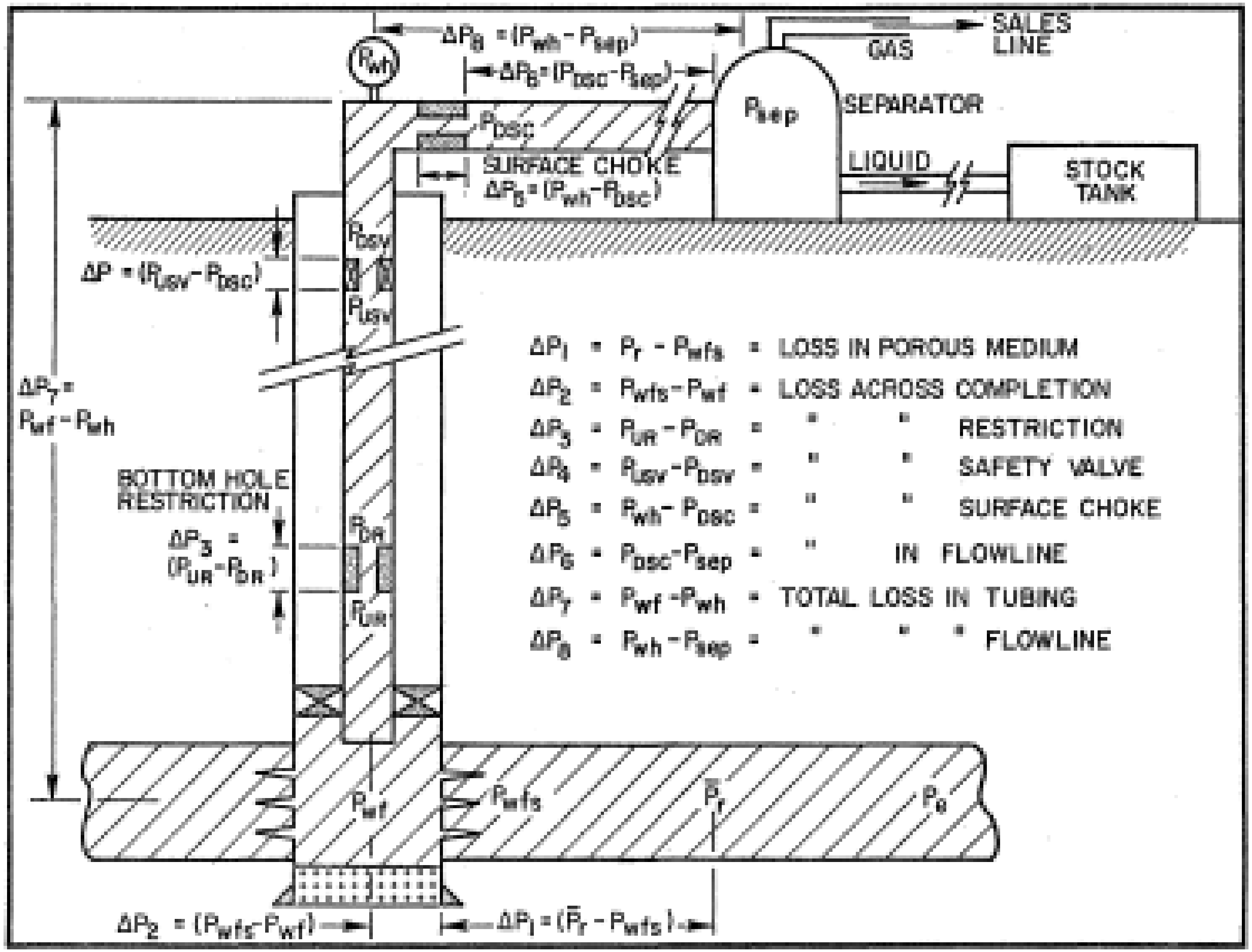


FIG. 2 POSSIBLE PRESSURE LOSSES IN COMPLETE SYSTEM

Inflow Performance Relationship (IPR)

- What is IPR? The ability of the reservoir to give up fluid
- Flow Regimes and Calculation of IPR
  - Transient
  - Pseudo-Steady State
  - Steady State
  - Above P_b, Straight line IPR (PI)
  - Below P_b, Vogel and Fetkovitch Equation

- Factors Affecting the IPR Curve?
  - Rock Properties
  - Fluid Properties
  - Reservoir Pressure
  - Well Geometry
  - Well Flowing pressure

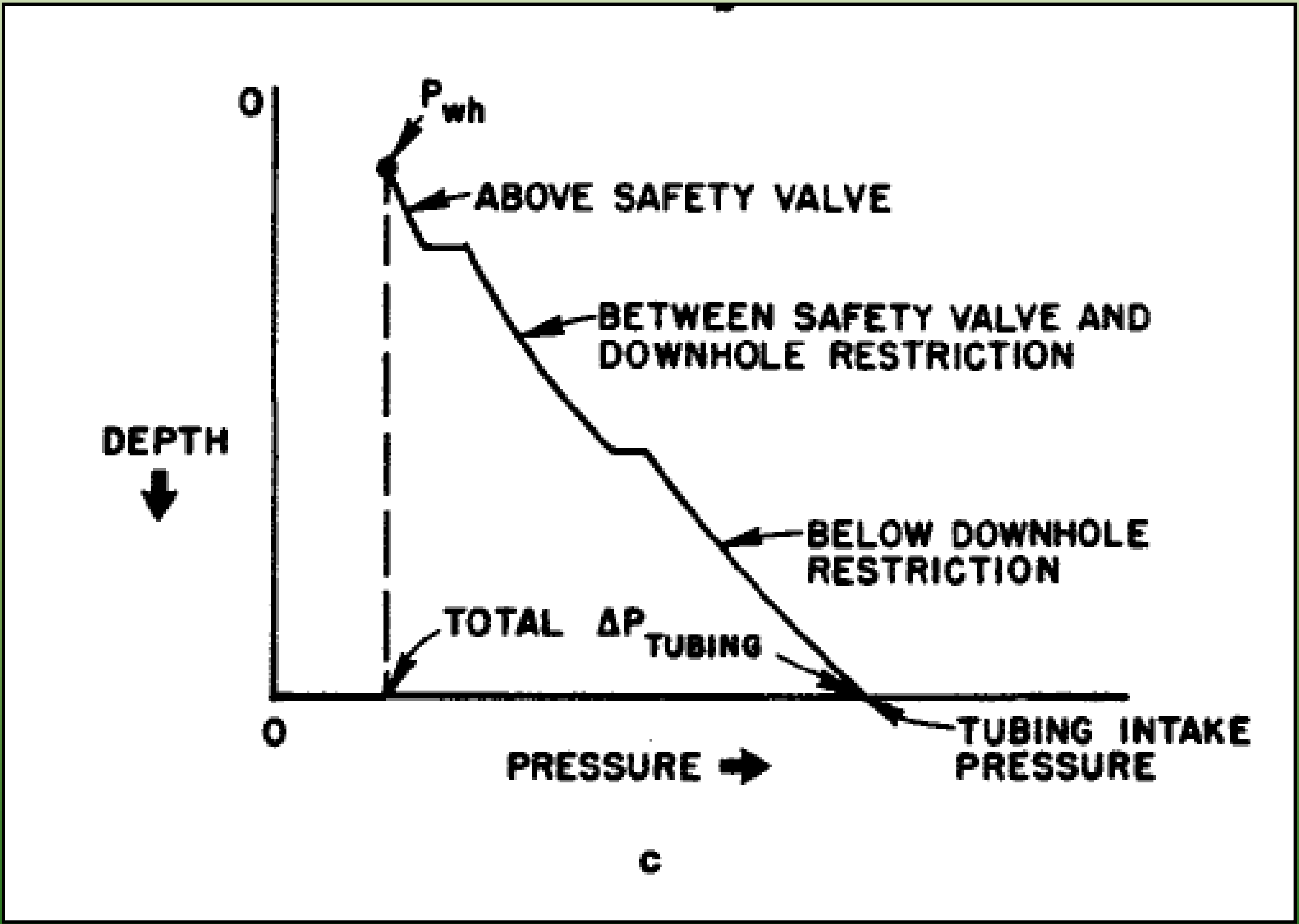
Vertical Lift Performance (VLP)

- What is VLP? This is a plot of the pressure traverse in the vertical/inclined tubing of a production system. It is a plot of the pressure losses vs. production rate in the system. Multiphase flow correlations are used in calculating the VLP.

- Vertical Lift Pressure Losses
  - **Hydrostatic losses-** Due to the density of the fluid column
  - **Frictional losses-** Due to the viscous drag
  - **Kinetic losses-** Due to the expansion and contraction of the fluid and the change in the cross-sectional area, which leads to acceleration and deceleration of the fluid

- Factors Affecting the VLP?
  - Production Rate
  - Well Depth
  - GOR/GLR
  - Tubing Diameter
  - WOR

Tubing Pressure Traverse



Calculation of the Vertical Lift Performance

Several Methods are available for predicting the pressure traverse in a tubing. The problem is complex because the flow is a Multiphase flow. The methods include;

- Empirical Methods based on Correlations
- Gradient Curves
- Mechanistic Models

Empirical Methods: Empirical methods are based on experimental studies and developed correlations. There are several types and each has a range of suitability depending on the fluid, the phases and the flow geometry. Examples of correlations under this include Duns and Ross, Orkiszewski, Hagedorn and Brown, Brown and Beggs, Beggs and Brills etc.

Gradient Curves- An example of this is Gilbert gradient curves. Gilbert was a production engineer with Shell and base on laboratory work and field data, he developed a set of curves for particular flow regimes. This curves give approximate values, but they are vey handy and fast for field applications. Pressure vs. depth is tabulated for different tubing sizes, GOR, GLR, and flow rate.

Choke Performance

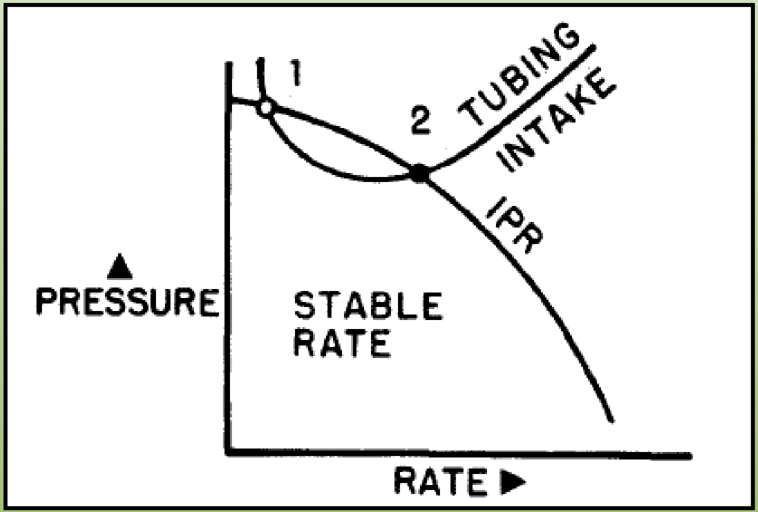
- Wells are usually choked in their early stages of production, but as reservoir pressure declines, they may be choked back and the choke removed.

- Chokes are used for the following reasons;
  - Safety
  - To maintain production allowable
  - To maintain a flow rate that would prevent production of sand
  - To produce the reservoir at the most efficient rate
  - To prevent water or gas coning

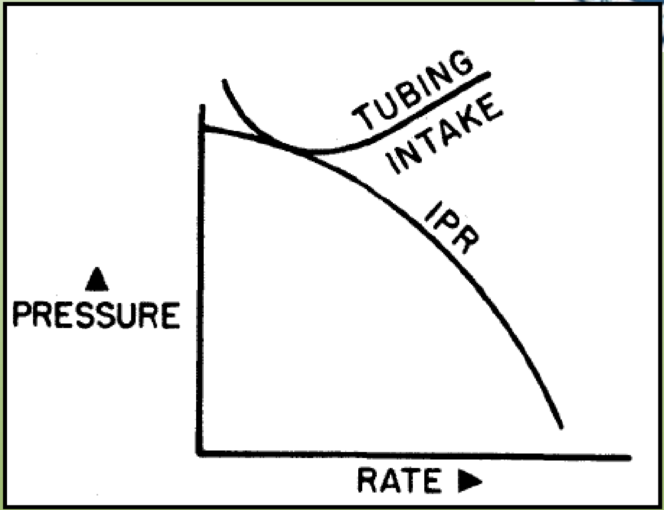
Well Deliverability

- Well deliverability is the stable rate a well can produce at determined from the combined plot of the well's inflow performance (IPR) and the vertical lift performance (VLP).

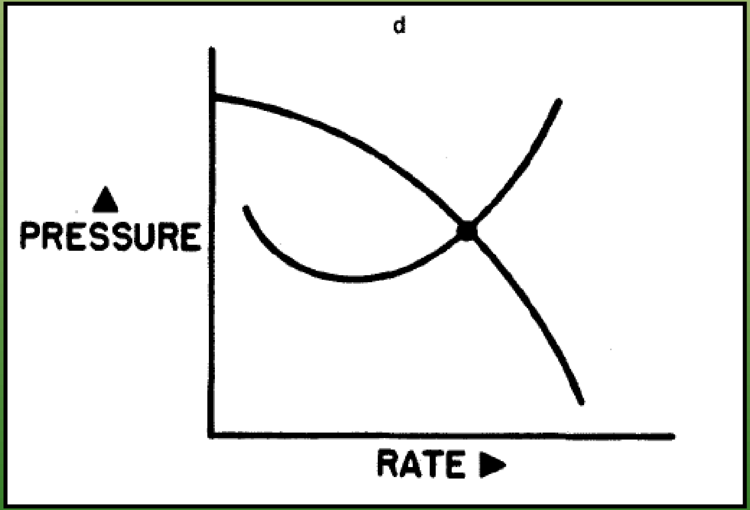
Well Deliverability



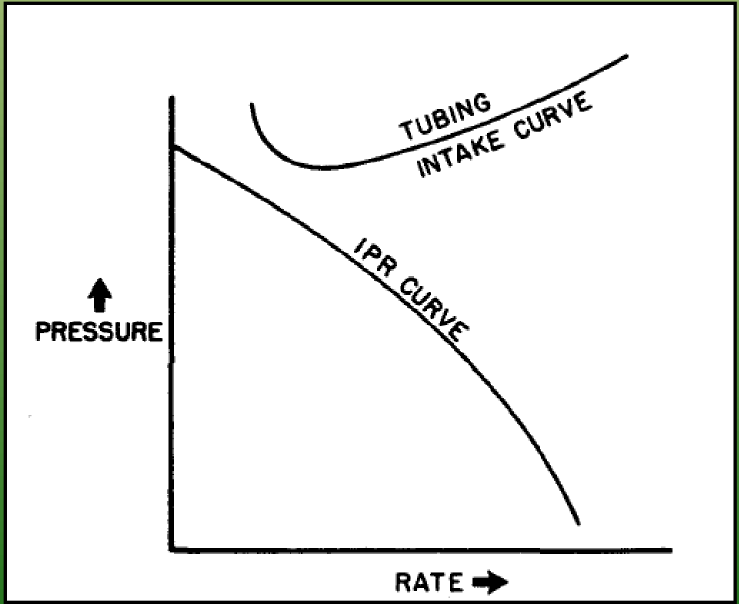
Flowing at 2



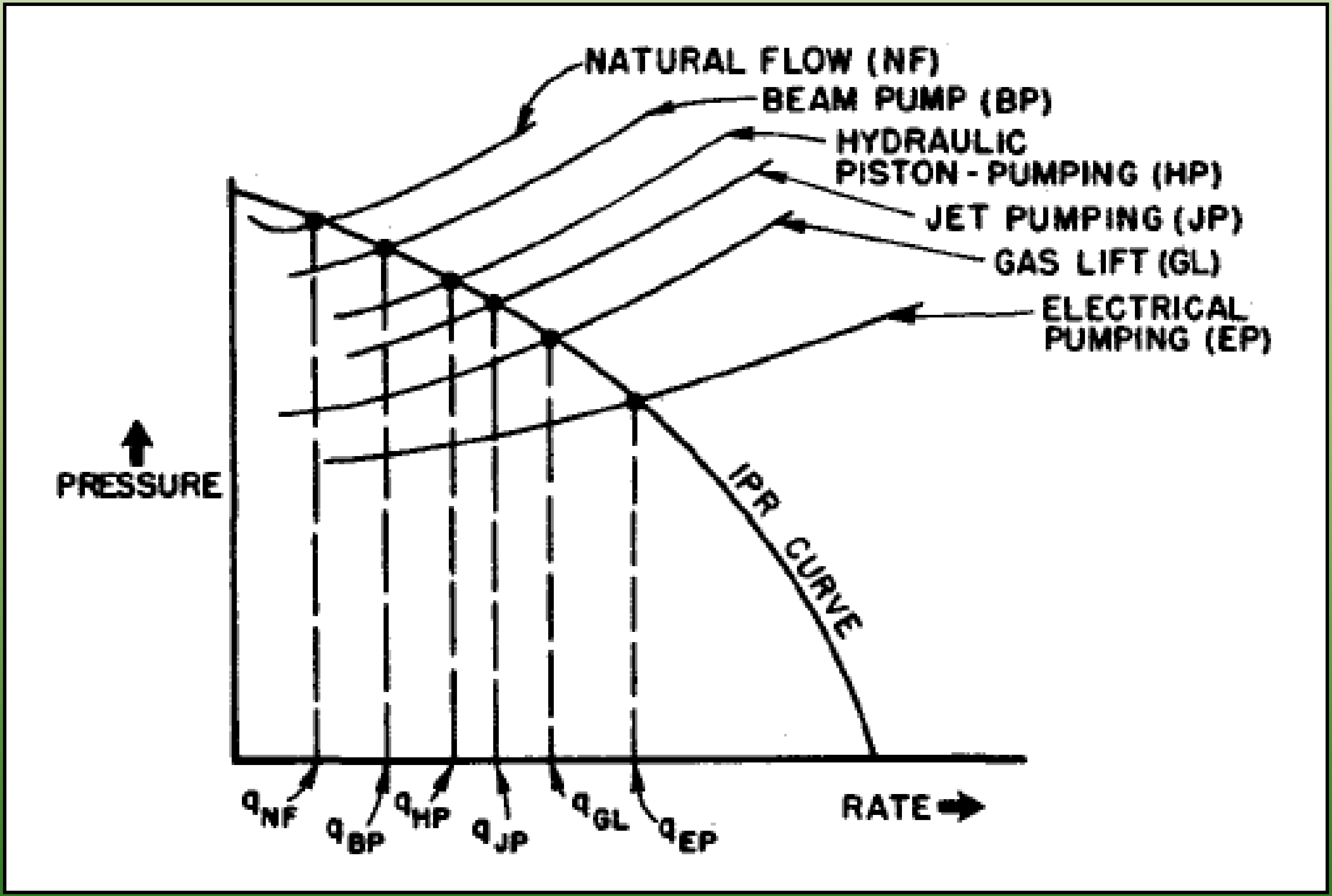
DEAD WELLS



Stable Flow



Tubing Intake Curve for ALS



Class Example- High GOR Well

Parameter	Data
Tubing Shoe Depth	11, 373
Tubing OD, in	4
Tubing ID, in	3.83
Surface Temperature, F	80
Bottom Hole Temperature, F	202
Static Tubing Head Pressure, psia	3370
Static bottom hole pressure, psia	6804
Measured Bottom hole pressure, psi	6152
Fluid Production Rate, stb/d	9922
Flowing tubing head pressure, psia	2191
Oil bubble point pressure, psia	4963
GOR, scf/stb	1375
Water Cut	0
Oil API gravity	45.7
Gas Specific Gravity, air=1	0.69

References

- Kermit Brown, “Overview of Artificial Lift Systems”, Journal of Petroleum Technology, 1982

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