

Short Course on
Petroleum Reserve Estimation,
Production,
and Production Sharing Contract (PSC)

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Gas Reserve Estimation

Gas Reserve Estimation

- Two methods for estimation of gas reserve.
- After discovery, during initial delineation and development of a field, volumetric estimation is the key to estimation.
- As depletion proceeds and adequate production data becomes, material balance may represent a practical second method. This eventually becomes most reliable method.

Gas Reserve Estimation

- Certain reservoir factors tend to reduce the applicability of material balance reinforce the importance of volumetric method throughout the life of the field.
 - Moderate to strong water drive
 - Low average permeability
 - Complex internal architecture and poor lateral or vertical continuity.

Presence of any of these factors may make it difficult to obtain a representative average pressure in response to production.

Gas Reserve Estimation

- **Methods of Estimating Reserves**
- **Volumetric Method, Deterministic Procedure**
- **Commonly used.**

- **Singular value or the best estimate for each parameter is used.**
- **Estimate of Reserves assigned to Proven, Probable and Possible categories.**
- **Based on the probabilities inherent in the estimates.**
- **Assignment as based on amount and quality of geological and engineering data available, availability of suitable analogous reservoirs and Evaluator's judgment as to the uncertainty inherent in the estimate.**

Gas Reserve Estimation

- Probabilistic Procedure
- More suitable for situation where uncertainty is high e.g. early stage of development, frontier areas.
- As level of uncertainty is increases – probabilistic procedure becomes more relevant. Rapidly expanding computer application also facilitating the use of probabilistic procedure.

Gas Reserve Estimation

Reserve estimation methods

- Volumetric
- Material balance
- Decline curve
- Reservoir Simulation

Gas Reserve Estimation

- **Volumetric Method**
- Most commonly used after discovery and early stage of production.
- Standard reserve equation with appropriate choice of parameter:
 - Area
 - Reservoir parameter (Area, Thickness, Porosity, water saturation, formation volume factor).
 - Recovery factor.

Gas Reserve Estimation

- Material Balance Method.
- Can be applied after obtaining certain amount of production data e.g.
 - Production Volume.
 - Reservoir Pressure and Temperature.
 - Fluid analysis data.
 - Log Data, Core data.
 - Drive Mechanism.

Gas Reserve Estimation

- Decline Curve Analysis.
- Analysis of production decline curve can provide estimation of three important items.
- Remaining Oil and gas reserves.
- Future expected production rate.
- Remaining productive life of well or reservoir.

Additionally explanation of any anomalies that appear on the graph is useful. Analysis is only valid provided that the well (s) is (are) not altered and the drainage is constant.

Gas Reserve Estimation

- Volumetric Estimate
- Volumetric estimate of hydrocarbon in place consists of the following steps:
 - Determination of rock volume (hydrocarbon saturated portion) from area and thickness.
 - Determination of average porosity.
 - Determination of water saturation to obtain hydrocarbon saturation.
 - Volume correction of hydrocarbon at atmospheric pressure and temperature.

Gas Reserve Estimation

- **Data used to estimate the gas reserve are seismic, well log, core data, bottom hole pressure and temperature data, fluid sample information, well test result. The data is used to develop various sub-surface maps (structural, isopach), cross sections. These graphics helps to establish the reservoir areal extent and help to identify reservoir discontinuities.**

Gas Reserve Estimation

- Volumetric result is useful in reserve estimation of gas in place at any time of depletion.
- Volumetric estimation is useful during the development period before reservoirs limit have been defined.
- Later in the life of the reservoir, when reservoir volume is defined and performance data are available, volumetric estimation provide valuable checks on gas in place estimates obtained from MB method.

Gas Reserve Estimation

- In North America in case of an isolated gas well with little or no geological control, it is frequent practice to assign reserve to one section (640 acre, 1 sq. mile), Depending on review of similar wells in the in a similar formation has satisfied the evaluator.
- For single oil well, the area assigned would generally be less for than for gas well because the flow characteristics for oil result in smaller drainage area. A typical practice is to assign proved reserve to area ranging from 1/4th section for light crude oil to 1/16th section or less for heavy crude oils.

Gas Reserve Estimation

- Determination of Area
- The parameter that often has the greatest variability in the reserve estimation is the area chosen to represent the areal extent of the pool.

Gas Reserve Estimation

- In Petrobangla, area for gas reserve estimation is considered at 3.14 Sq. Km or 716 acre. This equals to the area with in a circle of 1km radius.
- This area was introduced by the consultants from former Soviet Union.
- Oil & Gas Development Corporation, state own E & P organization of the then Pakistan was established during early sixties with technical assistance from former Soviet Union.

Gas Reserve Estimation

- Formula for estimation of oil reserve
- OIIP = Oil initially in Place
- $OIIP = VR \times \Phi \times 1/B_o \times (1-S_w)$
- VR = Rock Volume (Area x Average Thickness)
- Φ = Porosity
- B_o = Formation Volume Factor
- S_w = Water saturation

Gas Reserve Estimation

- Gas in reservoir occurred as
- Non associated gas
- Associated gas
- Solution gas.

Gas Reserve Estimation

- Gas reserve estimation
- Non Associated Gas:

$$G = VR \times \Phi \times (1-S_w) \times 1/Z_i$$

G = Gas in Place, VR = Rock Volume, Φ = Porosity,
T_{sc} = Standard base Temperature in Kelvin (273 + °C)
P_{sc} = Standard base pressure in Kpa,
T_i = Initial Formation Temperature (K),
P_i = Initial Formation Pressure (Kpa),
Z_i = Gas Compressibility factor at P_i and T_i.

Gas Reserve Estimation

- Associated Gas
- Gas associated with oil as gas cap is known as associated gas. During oil production period this remained shut in. Once most of the oil is produced, gas from gas cap is produced. Estimation method is same as described earlier.

Gas Reserve Estimation

- Solution Gas
- Gas liberated from the reservoir during oil production. To estimate the volume of this gas following formula is applied.
original
- $G_s = N \times R$

Gas Reserve Estimation

- To find out Z_i the following data is required
- Gas Composition
- Critical Pressure and Critical Temp. of individual component of the gas from reservoir
- Initial Reservoir Pressure
- Initial Reservoir Temperature