The Fundamentals Of Gas Lift

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The practice of lifting fluid from subsurface levels with gas pressure is not new; it has been in use for many years and is now recognized as a major method of artificial lift in petroleum production. Until recent years a detailed study of gas lift operating principles was relatively unimportant because of the low value of natural gas. With increasing gas value a study of the principles became imperative. This study has led to many advancements in development of the practice, principles and equipment.

Numerous types of wells with varying characteristics are encountered to be produced by gas lift operations, therefore, various types of equipment and installations are needed to meet these requirements. It is important that the basic principles of gas lift practice be thoroughly understood to insure correct selection of the type installation and equipment to be used for satisfactory results.

Operating Conditions

Well conditions under which an installation will operate govern the type installation and equipment that should be installed. With complete well data available, it is relatively simple to select and calculate an installation. With sufficient data available, it becomes necessary to assume or estimate factors which usually result in designing an installation to meet requirements beyond necessity. The following data, if available, is helpful in selecting a correct type installation and equipment to meet individual well conditions:

1. Total depth.
2. Size and weight per foot of casing.
3. Size and thread of tubing.
4. Type well completion, perforations, liners, open hole, casing seat, etc.
5. Static bottom hole pressure.
6. Static fluid gradient.
7. Productivity index.
8. Desired total fluid production per day.
9. Percentage of oil and water to be produced.
10. API gravity of oil.
11. Volume and pressure of available gas.
12. Surface restrictions. (Separator operating pressure, chokes, etc.)
13. Size and length of flow line.
14. Sand, paraffin, scale or corrosive potentialities.

It is rare that all this well data is available, however, all these factors should be considered prior to installing a gas lift installation. After all well data has been collected and evaluated, the well should be classified and decision made as to the use of intermitting type or continuous flow type of operation.

Intermitting Operation

The intermitting type of operation is used in a major portion of gas lift operated wells because of its flexibility. This type operation consists of injecting gas under a column of fluid at a pressure and volume sufficient to deliver fluid to the surface in a solid column with a minimum of aeration, slippage and friction. Intermitting flow is used in wells of comparatively low productive capacity or where the required working level is below the depth limits of continuous flow operation. It is used in both shallow and deep wells since the minimum and maximum operating depths are unlimited. There are many installations operating below a depth of 10,000' and operation can be established and maintained at greater depths when necessary.

The range of fluid producing capacity of intermitting flow depends upon (1) depth of operation, (2) operating pressure and (3) characteristics and gradient of fluid to be produced. Maximum fluid production is determined by the amount of fluid possible to produce during each cycle of operation and the number of cycles possible to complete within a specified interval of time.

The amount of fluid per cycle is dependent upon operating pressure and fluid gradient because in no instance can weight of the fluid column, in PSI, exceed the pressure, in PSI, required to force it to the surface. The maximum number of cycles per day is dependent upon the distance the fluid must travel and the velocity at which it travels.

With the operating level at shallow depths, it is possible to complete a cycle of operation as often as each five minutes, however, with the operating level at greater depths, for instance 8000' or below, it is rarely possible to complete a cycle of operation more often than each fifteen or twenty minutes.

With injected gas furnishing all lift energy and allowing for such factors as depth of operation, size tubing and operating pressure, a maximum daily fluid production of 500 to 600 barrels per day is possible from a depth of 5000' or less. From depths of 5000' to 9000', it is possible to produce 250 to 500 barrels of fluid daily. From depths below 9000' it is rarely possible to produce more than 250 barrels per day.

Continuous Flow

Continuous flow type of operation is accomplished by aerating a fluid column by continuously injecting gas into the column. Mixing the liquid and gas in this manner decreases the gradient of the column in the tubing to the extent that available bottom hole pressure of the well forces the fluid out at the point of surface discharge. Within the past few years rapid advancement has been made in the development of equipment and practice of producing wells by this method. Development of pressure controlled valves for this type operation allows surface control of operating input volumes over a wide range thereby improving the possibility of efficient and satisfactory operation.

In continuous flow operation daily fluid production is usually a major factor, therefore it is limited to wells with certain distinct characteristics, i. e., wells with high bottom hole pressure and high productivity indices.

It is difficult to establish a minimum fluid producing capacity for this type operation because of the many factors involved. Depth of working level, available surface operating pressure, fluid characteristics, bottom hole pressure, productivity index and size tubing are all major factors contributing to the producing capacity of a continuous flow installation. Under average conditions, however, it is possible to establish a broad rule by which wells might be classified as applicable for continuous flow.

A well should be capable of producing 300 barrels of fluid per day if 2" tubing is used and 500 barrels per day with 2 1/2" tubing. If the producing capacity of a well is less than these amounts consideration should be given to operating the well by intermitting flow. There is, of course, an overlap between the minimum quantity under continuous flow and the maximum quantity under intermitting flow. When well conditions are such that either continuous or intermitting flow is applicable, other conditions or operator's preference usually dictates the type operation employed.

The maximum fluid capacity of continuous flow operation is determined by (1) productivity of the well, (2) size of tubing, (3) operating pressure available and (4) fluid characteristics. Maximum capacity of 2" tubing is near 1200 barrels per day while that of 2 1/2" tubing is near 2500 barrels per day. In wells with unusually high productivity capacity it is possible to exceed these quantities.

Maximum operating depth of continuous flow operation is determined and limited by operating pressure, bottom hole pressure, productivity index and fluid characteristics. Formulae are available for calculating the operating depth, flowing gradient and productive capacities of continuous flow installations provided sufficient well information is available.

Well Characteristic Analysis

In order to classify a well as being applicable for continuous flow or intermitting flow operation, the following table is submitted:

Static Bottom Hole Pressure	*Productivity Index*	*Type Operation*
High	Low	Intermitting
High	Medium	*Continuous or Intermitting
High	High	Continuous
Medium	Low	Intermitting
Medium	Medium	†Continuous or Intermitting
Medium	High	Continuous
Low	Low	Intermitting
Low	Medium	Intermitting
Low	High	Intermitting

*Either operation applicable consistent with production desired and operating pressure.

†Continuous flow applicable only if bottom hole pressure is sufficient to support a flowing column desired for productive capacity.

Bottom hole pressures and productivity might be classified as high, medium and low approximately as follows:

Bottom Hole Pressures

High—If bottom hole pressure will support a fluid column equal to 70 percent or more of total well depth.

Medium—If bottom hole pressure will support a fluid column from 40 percent to 70 percent of total well depth.

Low—If bottom hole pressure will support a fluid column less than 40 percent of total well depth.

Productivity Indices

High—In excess of 1.00
Medium—From 0.30 to 1.00
Low—Less than 0.30

Operating Pressure

Operating pressure should be sufficient to produce the volume of fluid desired at reasonable efficiencies. In the event gas lift gas is obtained from a gas reservoir, the operating pressure may not be the same as that pressure available since allowance should be made for resevoir pressure decline. Should the supply be obtained by compression, pressure is dependent upon depth of operation, amount of fluid to be lifted and economics of compression. Excessive operating pressure for a required working level or for a certain amount of fluid may result in excessive compression costs and unsatisfactory operation.

For intermitting flow, the following table shows the approximate minimum requirements:

Operating Depth	*Pressures*
4000' and above	100 lb. per 1000' minimum 250 lbs.
4000' to 6000'	400 to 500 lb.
6000' to 8000'	500 lb. to 600 lb.
8000' and below	600 lb. to 750 lb.

For continuous flow, pressure requirements vary over a wide range and well characteristics are a more dominant factor than for intermitting flow. Formulae are available for determining the optimum operating pressures for given well conditions.

Equipment

Practically all gas lift equipment in use today might be classed as pressure regulators. A majority of all continuous flow and intermitting valves are merely back pressure regulators. The valves are placed at calculated positions in a tubing string to hold a predetermined annulus pressure. When the predetermined annulus pressure is exceeded a valve will open to pass the excessive annulus gas into the tubing. Fluid accumulated in the tubing above the valve that opens is blown to the surface.

Valve pressures are so calculated that the lowest valve in the string, exposed to annulus gas pressure, will open due to the increased annulus pressure, provided fluid level in the tubing is above the point of the valve in the string.

One certain type valve is dependent upon tubing pressure for operation. This type valve is usually referred to as a fluid operated valve. Essentially, the operation is not too different from the annulus pressure operated valve in that their flow may be classed as either intermittent or continuous. Only the means by which the valve is controlled is changed.

Efficiency

Numerous sources of energy loss contributes to the inefficiency of a gas lift installation. Loss of escaping gas through imperfect casing, tubing or surface connections are all factors of inefficient operation.

One of the major efficiency factors is operating personnel. Improper adjustment of chokes or surface controllers, caused by lack of knowledge or indifference, is probably the greatest factor contributing to inefficiency. All personnel connected with gas lift operations should be thoroughly versed in the mechanism of control for the various types valves in service. Efficient operation can be obtained only after personnel is educated in metering, chokes and surface control operation. Supervision provides the connecting link between the design engineer and field operating personnel. A well versed supervisor is of great assistance in obtaining reliable, satisfactory operation.

Surface equipment should be given periodic inspection to locate possible trouble in early stages. Maintenance of equipment in good condition is good insurance for trouble free operation. A designed installation is no better than the control will allow. The manner in which a well is initially placed in operation is important in assuring the best results.

Economics

Gas lift operations, when properly applied, are economically competitive to other types of artificial lift. Initial capital investment required for gas lift equipment, including equipment for closed rotative compressor systems, compares very favorably with the cost of other types of artificial lift equipment. Capital investment, however, is not the only nor the most important cost to consider. Operating and maintenance costs are exceptionally important items to compare as any lifting cost analysis will prove.

Gas lift operations become more and economically attractive as the depth of operation increases. Stresses and strains on the equipment do not increase in proportion to operating depth as is the case in most types of lift equipment, therefore, maintenance costs become less in proportion to comparable operating depths. Equipment development progress should further lower operating and maintenance costs of gas lift operations.