Well Testing

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Well testing, a broad general subject with as many different methods as there are operators, is a necessary part of determining the most efficient and conservative means of depleting an oil reservoir and the best method of lifting the fluid from a well from completion to depletion. An effort will be made at this time to present some of the uses of data obtained from well tests, precautions that should be observed in order to obtain usable tests and a general look at test equipment. The presence or absence of a regulatory body may govern the number of required well tests in any given State. As Texas has a regulatory body in the Railroad Commission, a brief discussion of the tests required in the State of Texas will be given. Other tests are left to the discretion of the operator for his use in efficient and economic depletion of the oil from his properties.

To begin this discussion let's take a look at the information that should be obtained and reported on a well test in order that a proper evaluation of the results may be made:

1. Length of test
2. Producing method
3. Choke size or length and number of strokes
4. Flowing pressure
5. Volume of oil produced
6. Volume of water produced
7. Volume of gas produced
8. Gravity of the oil

The well should be producing at a stabilized rate when the test is begun; that is, a well that has been shut-in longer than its normal shut-in time should be produced for several hours before the test is started or if a choke is changed or the pump stroke changed the well should be produced for several hours under the changed condition before a test is started.

Next consider the different types of tests which will be classified here as required and voluntary and further discussed as to the purpose of the test:

I. Required Tests
- a. Potential
- b. 30-day after potential
- c. General field surveys
- d. Special field surveys

II. Voluntary Tests
- a. Unitization
- b. Lease and well studies and evaluation
- c. Workover evaluation
- d. Secondary Recovery Project initiation and evaluation
- e. Design of lift equipment and surface facilities
- f. Marginal Tests

The initial test run on a completed well prior to placing the well on a daily production schedule is the potential which is required by the Railroad Commission of Texas. This test determines the capacity of the well or its potential to produce. It is used by the regulatory body to set the allowable rate for the well and gives the operator an idea of the time that will be required to recover the cost of drilling the well. This test should be run upon the completion of each new well and at the completion of workover operations.

The 30-day after potential test, required by the Railroad Commission of Texas, is a follow-up test to determine if the well is capable of producing its assigned allowable and if the gas-oil ratio has increased to a penalty rate.

The rules of operation of some fields, as set by the Railroad Commission, require periodic well tests of all wells in the field. These may be quarterly, semi-annual or annual and their purpose is to ascertain if the wells are capable of producing their assigned allowables and to determine if the field is being produced in a conservative manner, that is, are gas-oil ratios increasing too fast or are large volumes of gas being flared which should be marketed or put to some useful purpose. Periodically, if the Commission suspects waste, a special field survey may be called. This type survey is also a conservation measure.

In addition to the use the regulatory body makes of these tests, the operator may use the data in determining whether or not a well should be worked over, for lease or well evaluation, in prediction of well performance from past history, and in calculation of water and gas production as, in many fields, no facilities are provided for their continuous measurement.

Now let's take a look at the tests that are not required by the Railroad Commission. More and more fields are being unitized in order to provide more efficient operation, greater ultimate recovery and conservation of resources. Many unitization formulas include a production factor which is based on individual well tests which may be from three to thirty days duration. Oil, gas and water production are measured during this test and all or part of the wells participation in the unit may be based on the results of the test. An operator might decide, on the basis of the test, that a workover and retest is needed before the well enters the unit in order to increase its participation. The results of these tests are also used by the Unit Operator to determine the increase or decrease in producing capacity and the effects of fluid injection.

Operators find that well tests are a necessary part of any lease or well study. Well performance history, a-

vailable through well tests, assists in prediction of future yields, the value of a well in selling or purchasing property and the need for remedial work on a well. These performance tests can be used to distinguish between profitable and unprofitable wells.

Water intrusion and invasion can be traced through a field and its path predicted if a proper sequence of accurate well tests is maintained.

A comparison of well performance tests before and after workover operations is of great assistance in evaluation of the work and planning future remedial work in a field.

In the design of a secondary recovery program, the past history of the field as determined from well performance tests is of great value both in determination of the need for secondary recovery and the type of fluid to inject and the pattern for injection. Tests taken after the initiation of a secondary recovery project indicate whether the project is following predictions and whether success will be realized. A knowledge of the volume of water or gas produced from a secondary recovery project is as important to evaluation of the project as the volume of oil produced. As most operators do not meter or gauge the water production, the only way of obtaining a reasonable estimate of production is through frequent and accurate tests.

Design of the lift equipment for a well and the treating capacity of a lease require a knowledge of well capacities and estimated future fluid to be handled. This information is available upon analysis of well tests from that field.

Marginal well tests are reported to the Railroad Commission but are not required tests. Additional production may be obtained from a stripper well by placing it on a marginal basis producing 30 days each month. The marginal well test covers a 30-day period in which the gas, oil and water produced are measured.

The ideal test arrangement is for each well to produce into a separate tank battery with the oil, gas and water measured each day. Operators find this wasteful and utilize one battery for several wells. A test of each well in the battery once a week would be desirable; however, economics and the number of wells in each battery prevent this. Tests each month are considered adequate in most cases. Many operators find that they have tests reported only once a year and consider this sufficient. For a well or lease study annual tests may prove inadequate and it is a fortunate operator who is able to take tests after they are needed.

The length of each test will vary with the well capacity and producing method. Capacity tests of some wells would require permission of the regulatory body. It is desirable to test each well over a 24 hour period and under normal producing conditions. as shorter tests prorated to twenty four hours are subject to a magnification of any error in the shorter test. Take an example of a four hour test recorded as 24.5 barrels instead of 25.5 barrels and resulting in an error of 6 barrels per day when prorated to twenty four hours. An error of this amount may easily occur when the water production must be bled from the tank or is calculated from shakeout percents. The gas-oil ratio may also be affected if the prorated volumes are used in the calculations in place of the actual test volumes. The above example illustrates how small, unimportant errors may multiply and introduce serious error when combined with other tests for lease or field studies. Thus, we find the length of the tests may cause a profitable venture to appear less attractive or have the opposite effect.

Measuring the oil, gas and water produced in a given period of time is the object of any well test. The advantages of longer tests have been discussed above and the mechanics of measuring each different fluid and some of the equipment available are discussed below.

Various types of mobile equipment (test tank with separator mounted on a skid and horizontal or vertical separators with necessary fluid meters mounted on a trailer) that utilizes basic testing principles are now in field use. The difficulties encountered are the same whether tested at the battery or with mobile equipment.

Oil production may be measured by meters or tank gauges. Meters in common use are of three general classes; positive displacement, velocity and gravi-metric. The accuracy of an oil meter is greatly affected by dissolved gas, emulsified water, suspended solids, and variation in physical properties of the oil. Advantages of meters include adaptability, speed and ease of movement. Protection from excess pressures and abuse should be standard practice for all meters and the meter should be recalibrated periodically.

Positive displacement meters are more accurate for large volumes and higher rates of flow. Velocity type meters, orifice and venturi, can be extremely accurate if proper precautions are taken in taking the test and reading the results, however, this type meter is not as rugged as the positive displacement meter and is not as suitable for field use.

Meters recording by weight rather than volume eliminate a temperature correction and compensate for entrapped gas; however, emulsified water may nullify any advantage gained. These meters also require an adjustment of the recorded volume for each different oil gravity. It is advisable to have an adequate sampling device near the meter in order to know the type fluid metered. All meters should be calibrated and checked with tank measurements periodically to secure maximum accuracy.

Tank gauges are generally accepted as the most accurate means of measuring oil; however, certain precautions should be followed to prevent errors. All water and basic sediment should be bled from the tank prior to gauging to start the test. At the completion of the test a gauge should be taken, the free water bled off and gauged again. The importance of figuring the production by reading the volumes for each gauge and subtracting is very evident when using a horizontal steel or an elliptical wooden tank but also holds true for vertical steel tanks. Horizontal tanks are generally equipped with a gauge guide that may not be equalized with the tank level while production is entering the tank. All gauges should be taken without the disturbance of production entering the tank. A difference of three to six inches above the true gauge has been noted when production was allowed to enter as the gauge was taken.

Oil may not be free of water or solids and the volume is needed at once. The water percent of samples taken at various depths of the tank may be averaged and used to figure the oil volume. A sampling device, as mentioned above, set to trap a small portion of each barrel of metered fluid will secure a representative sample of the entire volume. The oil percent of this sample may be used to calculate the volume of oil metered. A volume thus calculated is subject to two errors; the accuracy of the meter and the accuracy of the sample. Another method used by some operators is to secure a well head sample at given intervals and to average the values without regard to the volume of fluid produced during the intervals covered. Great inaccuracies may result from this method.

Gravity of the free oil should be reported on each test. Care should be taken in making the correction for temperature and for water in the sample used.

It is important that the measurement of the gas produced during a given test be accurate. Well tests reported during a survey help to make necessary changes in allowables and gas production in excess of the allowed field ratio will bring a cut to that well.

The Railroad Commission of Texas publishes "Pamphlet for Gas-Oil Ratio Determination" that will serve as a guide in your work. Gas measured at conditions other than 60 deg. F, 0.6 specific gravity and 14.65 psi must be corrected to these conditions prior to reporting the volume to the Commission. Southwestern Gas Measurement Short Course held each year at Norman, Oklahoma covers gas measurement in detail.

Various gas measuring devices are available to the industry; orifice well tester, critical flow prover, open flow pilot tube and meter run, to name a few. Pressure devices used with the above mentioned measuring equipment may be recording or instantaneous reading.

The orifice well tester is used for measuring volumes of gas. It consists of a special two inch nipple fitted with a pressure connection, an orifice disc; a gasket and a cap for holding the orifice in place on the end of the nipple. The pressure connection is tied to a recording pressure gage or a manometer after the nipple has been attached to an appropriate connection

in the vent line from the separator. This device is most accurate if an orifice plate is used that keeps the working pressure near the center of the pressure range. Orifice well tasters are available in three inch and four inch sizes for larger volume of gas.

A critical flow prover, similar to the orifice well tester, is used for large volumes of gas and may be used in flow lines. This type of meter is not in common use in the field.

An open flow pitot tube measures impact pressure and should be used only when other measurement methods are not available.

The two, three or four inch meter run fitted with a suitable recording pressure gauge is considered the most accurate field method of measuring gas. An orifice flange is installed in the gas vent or flow line and an orifice plate of the desired size installed. Pressure taps are installed in the flange or the pipe and the recording instrument is attached at these points. Sufficient straight pipe is installed in the meter run to insure a minimum of turbulence and swirling when the gas reaches the orifice. Straightening vanes are set ahead of the orifice plate when it is not possible to have the straight pipe. The upstream and downstream pressures are measured and with the appropriate correction factors are substituted in the gas formula.

Produced water may be measured in the same manner as the oil. Again care should be taken to know the type of fluid measured. A well with a very high water-oil ratio may present as much difficulty with oil in the metered water as is found with the reverse situation. Several water level finding devices have been marketed for use in a tank. Some examples of those that have been used are as follows:

Paper coated with colored material soluble in water but not oil.

Colored paste that changes color upon contact with water.

Ebony wood that is wetted by water but not oil.

Molasses on the gauge rod.

Chalk on the gauge pole.

A thief may also be used to establish the water-oil contact in a tank and/or the amount of water present in the oil. Bleeding the water from the tank and using the different gauges to calculate the water produced has its merits but is only as accurate as the care taken. On a large tank the oil may prematurely come down to the drain. This is generally the result of too high a bleed-off rate and may cause the water production to be reported low. Comparing the average volumes of one half an inch of water in various size tanks we find for a low 250 barrel tank it is 1.38 barrels, a low 500 tank 2.70 barrels and a high 200 tank 0.49 barrels. The importance of this may be lost to you until you consider that every well will some day be a stripper and the production will be evaluated for economy of operation. Water counted as production would certainly give a false picture.

In summary, we have tried to show how the monthly well tests fit into the overall operational picture. The need for sufficient and accurate well tests cannot be over emphasized as the decision to spend large sums of money to rework wells, to institue secondary recovery methods or even in routine development of a field depend, at least indirectly, on information gained from well tests. It is hoped that you have had recalled to your attention some of the limitations of testing and the importance of accurate tests and that you will not only apply them but will pass them on to your associates.