The Lease Pumper's Handbook

Chapter 15
Enhancing Oil Recovery

Section B

PRIMARY RECOVERY

B-1. Primary or First-Stage Recovery.

During the past 100 years, many innovative methods have been used to enhance first-stage recovery. Although no additional force is added into the formation on a continuing basis, many enhancing workover jobs involve procedures that are extended deep into the reservoir—such as fracing, chemical treating, and, more recently, horizontal drilling. Outstanding primary recovery or well treatment practices that continue to enhance recovery include:

Production allowables and productivity testing. Placing allowables (production limits) on some wells by company or regulating agencies can significantly extend the life of the wells and greatly increase long-range recovery. When several companies are producing from the same reservoir, oil companies may request regulations that limit production to protect their wells from offset operators who may abuse the reservoir through overproduction.

Through productivity testing on a scheduled basis, wells can conserve gas pressure and produce more oil for a longer period of time. The goal is to reduce gas production while stimulating oil production. Conation of water and gas can be reduced and controlled if the lease pumper understands what causes these problems and how to avoid damaging the wells.

Sand and acid fracing. Fracturing or *fracing* methods are techniques used to made the formation more porous. Sand fracing stimulates wells by using sand to prop open a formation. Acid fracing uses acids and other chemicals to etch openings in tight formations. These treatments continue to be popular and contribute to increased recovery in tight formations with low porosity.

Other fracing procedures such as the use of heat and pressure are also gaining in popularity. Newer technology includes the addition of tracers while fracing to control reservoir damage.

Stabilizing formation sand and scale. These two enhanced recovery procedures continue to be improved through research and technology. Sand and scale in the formation are stabilized by pumping chemicals into the reservoir. This produces more fluids with fewer problems. Important considerations in these procedures are location and relationship of casing and tubing perforations, as well as sand screens and gravel packing.

Echometer, dynamometer, gas lift, plunger lift, and other well analysis and automation control systems. During recent years, great strides have been made in many methods of automating producing wells with computer-controlled systems that obtain maximum production, lower lifting costs, and identify well problems as soon as they occur. These systems continuously analyze production, control well production, and make changes in production time. They also print out a daily well analysis report detailing well problems.

Hydrotesting, tracer surveys, well logging, and other surveys. These procedures can provide information that is valuable in deciding what types of enhancements may be effective.

Moving the casing perforations up or down the hole. When a well extends many feet into the reservoir, perforations need to be moved up or down the casing in order to restore production. This need is determined by the type and shape of the formation, how the well was originally completed, and the type of drive in the reservoir. Some strata also have impervious layers within the reservoir that separate sections that produce at different rates. The location of tubing perforations in relation to casing perforations also dramatically affects the production from each well.

Changing lift systems. During the life of a well, the lift system may need to be changed several times as performance changes. For example, a well may have flowed when first drilled, then later placed on gas lift, followed by mechanical lift, hydraulic lift, back to mechanical lift, and finally had a beam gas compressor added. Selecting the type of artificial lift is always a best-guess decision.

The number of activities that may enhance production from the wells requires the lease pumper and the lease operator to continuously study all wells to enhance production and make surface and wellbore changes to meet changing reservoir conditions. When the production of a well dramatically falls, sometimes it is very difficult to analyze the root cause of the problem and decide what corrective action must be performed. Many analysis methods are available and it is always a difficult choice to select the best methods for finding the answers. Many times wells are plugged too early in their producing life because the lease operator never identified the true problem that caused the loss of production and workover procedures did not solve the problem. This can occur even with outstanding operators.

B-2. Production Stimulation Through Horizontal Drilling.

The greatest technology advancement in drilling procedures in recent years has been the development of the equipment and techniques used in horizontal drilling. The controlled ability to deviate drilling from a vertical direction to a controlled horizontal direction has revolutionized the industry.

Along with the development of these techniques came the innovation of a drill bit and mud motor assembly with a slight bend in the middle. The next development was efficiency in tracking and orienting the mud motor; so the rig could continue to drill with the drill string not rotating while the bit was turned by the mud motor.

By turning the drill string, the bit drilled straight ahead with a wobble, but with stable motion and not greatly increasing the hole size. With the pipe standing still and the mud motor turning, the direction being drilled can be corrected or changed with orientation control.

With these improved techniques, a rig can drill down near the reservoir, turn horizontal in the oil producing zone, then drill for more than a mile in the pay zone. This drill and completion technique exposes so much open reservoir hole that it will increase production from the new well many times over previous drilling methods.

Many older wells are also being worked over using this technique. After workover, many wells produce more oil than when they were originally drilled. The success of horizontal drilling has been phenomenal, and the procedure continues to be improved. The ability and skill of the horizontal drilling specialist supervising this procedure and the correct interpretation of well logs greatly affects the success or failure of these production enhancement objectives.

B-3. Beam Gas Compressors.

The movement of gas in the reservoir stops when the pressure of reservoir gas is equal to the weight of the fluid column and the resistance in the flow line and tank battery. Production of oil falls to zero. It becomes necessary to either plug and abandon the well or find another solution that will restore enough production to extend the producing life of the well.

Figure 1. A typical beam gas compressor.
(courtesy of Permian Production Equipment, Inc.)

One option available is to install a *beam gas compressor* (Figure 1). The design of a beam gas compressor allows it to pull gas from the casing and reservoir, compress it, and inject it into the flow line downstream from the flow line check valve. This can remove backpressure from the formation and allow fluids to migrate to the wellbore again.

The pumping unit supplies power to operate the compression cylinder. Many stripper wells have increased their daily production 300% or more with this system. This increase in income can pay for the equipment on many wells in just a few months. The compressor cylinder compresses gas on both the up and the down strokes with no lost motion. Operation of a beam gas compressor is shown in Figure 2.

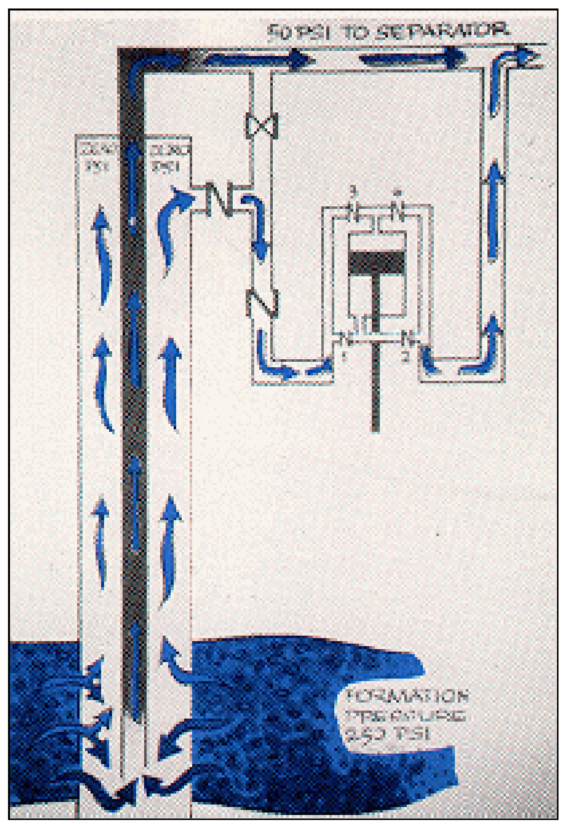

Figure 2. Beam gas compressor operation.
(courtesy of Permian Production Equipment, Inc.)

B-4. Venting Casing Gas at the Wellhead.

When the volume of gas being produced from the well has been reduced to *trace* levels, another method to stimulate oil production may be used. This is to open the casing valve to the atmosphere and allow the casing pressure at the surface to fall to zero.

Although this volume of gas is extremely small, this production procedure will remove backpressure from the casing and formation and allow it to begin producing again.

When venting the gas at the wellhead by barely opening the casing valve, oxygen can enter the top of the casing and can contribute to oxygen corrosion. To reduce oxygen corrosion, some operators install a ball and seat standing valve from a downhole pump placed vertically in the casing opening. The weight of the ball seals out oxygen and only a few ounces of pressure remains on the casing.

A hose from the tubing bleeder valve into a swage in the casing valve will allow the pumper to visually check well performance easily. The produced liquids are bled back into the casing, which is coated with oil as it falls back to the bottom of the hole. This oil coating can also assist in preventing oxidation.

Since implementation of this procedure involves merely opening a casing valve, it is a popular way to extend well life.

B-5. Perforation Orientation.

Perforation orientation includes two areas that affect the well's ability to produce crude oil. The first is a review of the location of perforations in the formation. The second is to determine if oil production can be stimulated by closing off these perforations and moving them either up or down the hole.

Raising casing perforations. When wells are completed in water-drive reservoirs that are many feet thick, perforations may be placed above the water/oil interface level but below the gas zone. Eventually, the water table in the reservoir rises, and water production from the well increases. Perforations then need to be cemented off, and the well re-perforated at a higher level. This will restore part of the oil production, lower the water production, and extend the life of the well.

Lowering casing perforations. With a well produced in a gas-drive reservoir, the oil level will lower in the formation and the well will begin to produce more gas and less oil.

Overproducing gas from the well can result in several undesirable results. The first is caused by bleeding off the formation gas. This continued lowering of the gas pressure results in a like reduction in oil production. The second condition that it sets up is to allow water to rise in the reservoir if it is also water drive.

By cementing off top perforations and re-perforating lower perforations, oil production may again increase and gas production may be reduced. Before perforations are lowered, a plunger lift may need to be installed or a pressure maintenance program implemented to slow down gas loss.

Tubing/casing orientation. One of the procedures that must be determined by the lease operator is deciding where tubing perforations will be placed in relation to casing perforations. They can be placed above, even with, or below casing perforations.

Different companies have different reasons for deciding where they orient the tubing perforations in relation to the casing perforations. This orientation not only affects the amount of fluid that will be produced, but it also maintains a fluid or gas blanket on the formation and a small pressure against the formation. It also to a small degree affects paraffin and scale problems that may be encountered in the perforation area and the tubing.

B-6. Innovative Procedures.

The skill needed to produce marginal wells demands a close study of what is occurring to the wells, an understanding of how the wells were completed, what changes will be required in the future to maintain profitable production, a keen understanding of when these changes must be made, and having the desire to study and try to continuously enhance production.

One of the most important requirements in lease production enhancement is controlled by the lease pumper. This person must develop a deep understanding of production, make good decisions daily, and work consistently at the job. The pumper should keep the following factors in mind:

- Type of reservoir.
- Flow at each well. Is it increasing?
- Does the efficiency of the chemicals need to be retested?
- What are offset operators doing to stimulate production?
- A large pump moves liquid quickly. Is this the best way?
- A small pump moves liquid slowly. Is this the best way?
- Frequency of pump repairs.
- Setting of tubing perforations in relation to the casing perforations.
- Flow line backpressure against the formation.
- Should the type of mechanical lift be changed?
- How long has it been since the last productivity test?
- Pumping unit strokes per minute.
- Pumping unit stroke length.
- Causes for down times.
- Changes in production profiles.