A Primer of Oilwell Service, Workover, and Completion

First Edition

PETROLEUM EXTENSION SERVICE ❖ THE UNIVERSITY OF TEXAS AT AUSTIN

CONTENTS

FIGURES

I

INTRODUCTION

A newly drilled oilwell is not much more than a lined hole in the ground. When a drilling crew drills a well, they line it with large pipe called *casing*. They also cement the casing in the well (fig. 1.1). At this point in the well's life, it usually cannot produce oil and gas (*hydrocarbons*). The company that owns the well—the operator, or operating company—has to *complete* it. The operating company completes the well by adding equipment and carrying out certain procedures that will allow the well to produce fluids (oil, gas, and water).

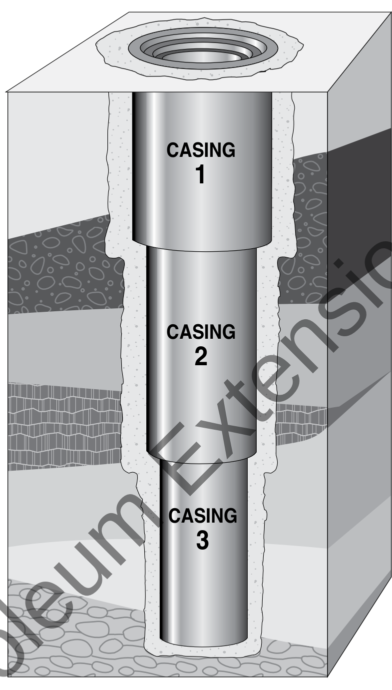

Figure 1.1. A newly drilled well lined with cemented casing

To complete a well, a crew usually installs a string of relatively small pipe—*tubing*—inside the well. Near the bottom of the tubing, crewmembers usually install a special sealing device called a *packer* and connect valves and metering devices on top of the well to control flow. Sometimes, crewmembers add a pump or another device to lift the oil out of the ground.

As wells produce over time, equipment fails and the rocks holding the hydrocarbons—the *reservoir*—cause problems. When problems with equipment and the reservoir occur, flow from the well either slows down or stops altogether. When this happens, the operator also has to repair and work on the well to bring it back to full production. The industry calls such repair and work *well servicing and workover*. The operating company customarily hires a well servicing and workover company, or contractor, to do well repair and other remedial work.

Well servicing is maintenance work. It usually involves repairing equipment, but a servicing contractor may also add new equipment to restore the well's ability to produce hydrocarbons.

Workover includes any of several operations on a well to restore or increase production when a reservoir stops producing at the rate it should. Many workover jobs involve treating the reservoir rock rather than the equipment in the well.

Well servicing and workover are important because oil is the most heavily used energy source throughout the world. The U.S. Geological Survey has estimated that 70 percent of all hydrocarbons on earth have been discovered. Of these, 32 percent have been produced and consumed. The undiscovered 30 percent is most likely in small fields in difficult environments like the polar regions and under the seas and oceans. These environments are extremely expensive to drill in.

2
WELL COMPLETION

After a drilling crew has drilled a hole to the reservoir and lined the hole with pipe, it may or may not do the additional work needed to get the well into production. Sometimes crewmembers move on to drill another well, and a well servicing crew comes in to add the equipment needed to start the hydrocarbons flowing, or to complete the well.

Completion begins with installing tubing inside the casing to provide a flow path for oil and gas. The completion crew sets a seal called a packer to seal off the space between the tubing and the casing and installs a wellhead to control the flow of the reservoir fluids. Finally, the crew may install equipment such as a pump to lift oil to the surface, if natural drives cannot force it up.

CASING

Let's begin by reviewing the pipe, or casing, that lines the hole from the start of drilling to the end. Threaded couplings connect each joint of casing to form a *casing string*, which is the entire length of the casing. A cementing crew cements a string of casing in the hole as it is drilled; therefore, casing is not easily removable.

During drilling and completion, the crew runs several strings of casing into the hole. Each casing string fits inside the last, so each string is smaller in diameter than the one set before it (fig. 2.1). The first string is the *conductor casing*, a relatively short string (20 to 100 feet, or 6 to 30 metres) of large-diameter pipe that keeps the top part of the hole from caving in during drilling. The crew then drills below the conductor casing to just past the depth of the deepest fresh water in the formation.

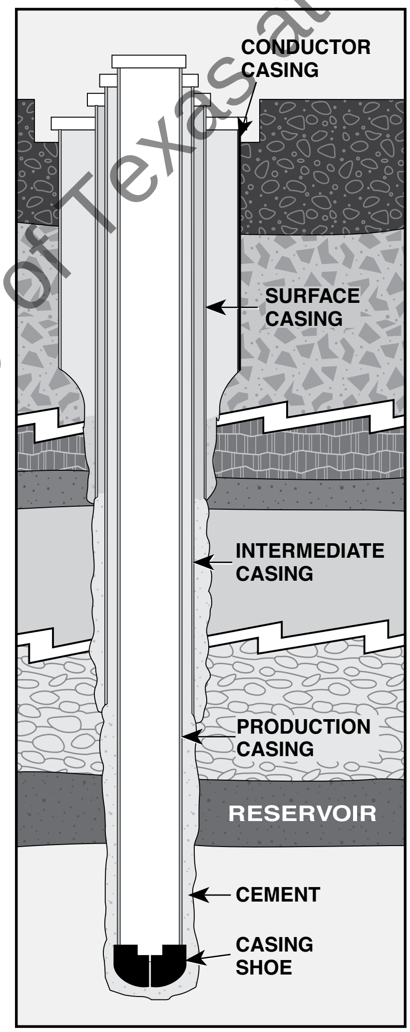

Figure 2.1. Concentric strings of casing line the drilled hole.

3

ARTIFICIAL LIFT

After tubing has been run in, the packer set, and the well perforated, hydrocarbons usually flow to the surface immediately or after a crew swabs the well. When pressure from natural reservoir drive falls to the point where a well cannot produce on its own, however, an artificial method of lifting the hydrocarbons is necessary. Artificial lift is most commonly provided by some sort of pump or a method that involves injecting gas into the well.

BEAM PUMPING

By far the most common method of artificially pumping oil from the formation to the surface in land-based wells is beam pumping. A *beam pumping unit* sits on the surface (fig. 3.1). It sends an up-and-down motion, called *reciprocating action,* to a string of rods called sucker rods. *Sucker rods* are solid, high-strength steel (or sometimes fiberglass) rods connected together. The top of a sucker rod string is attached to the front of a pumping unit, usually to a walking beam, and hangs down inside the tubing. At the end of the string, near the bottom of the well, is a sucker rod pump. The walking beam's reciprocating action moves the rod string up and down to operate the pump.

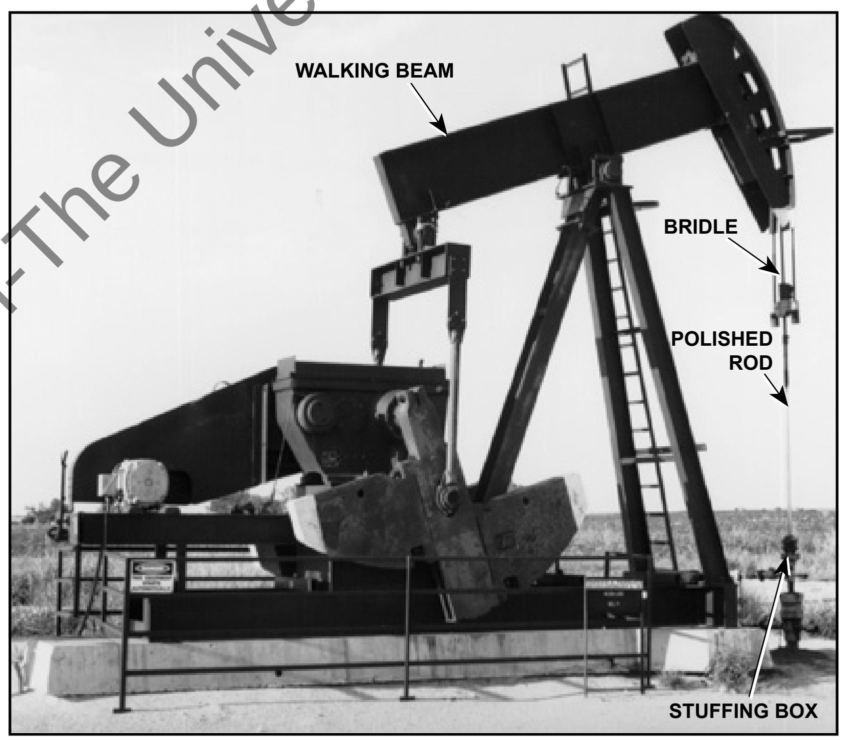

Figure 3.1. The beam pumping unit is a familiar sight in oil country.

4

LOGGING AND TESTING A WELL

Logging and testing wells occur during drilling, completion, service, and workover. Logging and testing specialists use many types of instruments and techniques to reveal information about the condition and location of the reservoir, formation fluids, wellbore, circulation fluids, and equipment in the hole. This chapter is an overview of some of the main types of logs and tests.

A *log* is a permanent record of information about the formations a well has drilled through. There are many ways to log, or survey, a well. Some involve observations of the drilling conditions and rock, and others involve lowering a tool into the well that sends signals to an observer on the surface.

DRILL STEM TEST

The drilling crew runs a drill stem test (or DST) to test a formation it has just drilled into. The DST gives accurate data about a formation's pressure and the composition of the fluids in it. A DST tool is run in on the end of the drill stem (fig. 4.1). It has one or two packers that isolate the zone to be tested. A perforated pipe between the two packers, or between one packer and the bottom of the hole, allows formation fluids to flow in. A pressure recorder inside the tool above the packer and another below the perforated pipe chart the pressure. When the pressure testing is finished, valves in the DST tool close to trap a fluid sample, the packer is released, and the tool is retrieved.

Analyzing the DST reveals reservoir pressure, average permeability, the presence and location of permeability changes, formation damage, production potential, and pressure depletion rate.

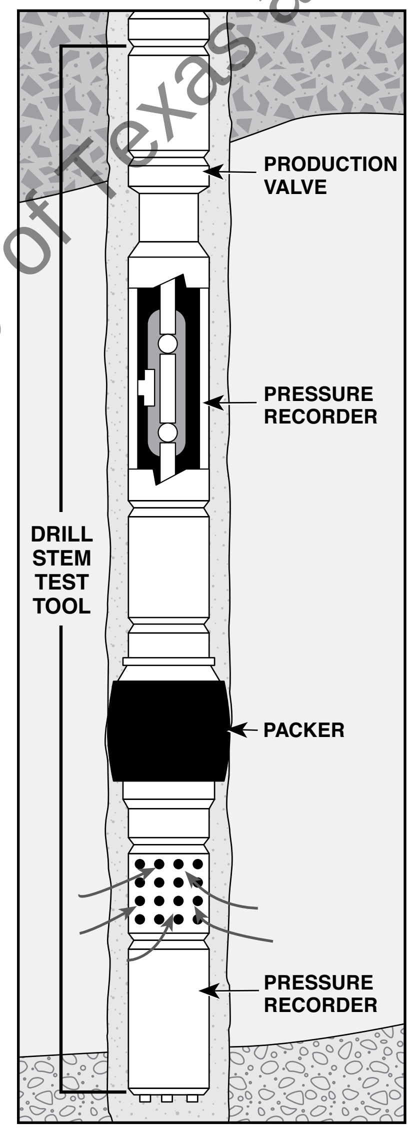

Figure 4.1. A drill stem test tool records pressure and samples the formation fluid.

5

ANALYZING A WELL

Working on an existing well to restore or increase oil and gas production is an important part of today's petroleum industry. Oil companies decide whether to service or work over a well based on two main factors: supplies of oil and gas, and their prices in the marketplace.

When oil prices are high, oil companies invest in drilling new wells because they expect to recover the costs quickly. In 1979 through the early 1980s, for example, oil sold for about $35 a barrel, and an average of about 3,000 wells a month were being drilled in the United States. In 1986, the price had dropped to about $10 a barrel, and only about 800 wells were being drilled a month in the United States. Fewer new wells means the proportion of older wells increases, and older wells need service or workover.

REASONS FOR SERVICE OR WORKOVER

A well that needs service or workover is not producing at all or is producing hydrocarbons at a rate not up to full potential. Six general types of problems may call for a service or workover contractor: (1) excessive gas production, (2) excessive water production, (3) poor production rates, (4) production of sand, (5) equipment failure, or (6) depleted reservoirs.

Excessive Gas Production

In wells with a gas-cap drive, the natural gas expands as liquids flow out (fig. 5.1). Originally, perforations in the casing are well below the gas cap, but eventually the gas cap expands below the perforations. The well then starts producing a lot of gas with the liquids. Excessive gas production depletes the gas, driving the oil out of the reservoir.

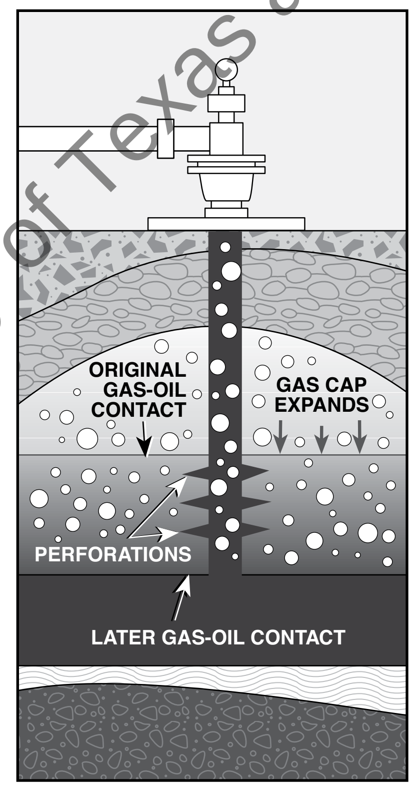

Figure 5.1. As oil is produced, the gas cap expands and reaches the level of the perforations in the casing or liner.

6

SERVICE AND WORKOVER EQUIPMENT

Before the 1950s, rig builders usually built a permanent derrick at each well for drilling and maintenance of the well throughout its life. Now, however, the whole drilling rig is moved to a new site when drilling is finished. The well is left with only a wellhead and sometimes a pump, so service and workover companies must bring the equipment they need to work in the well.

The amount and type of equipment they need depends on the job. One job may require a light-duty rig and a couple of workers. The next well may need a somewhat larger rig with a tall mast and a crew of several workers. Another job may require extra crews to work around the clock and a rig capable of light drilling and heavy-duty hoisting.

RIG EQUIPMENT

Service and workover rigs, like drilling rigs, are machines for hoisting pipe, wireline, and tools into and out of a well. They have a derrick or mast, a drawworks, and a power source. Unlike drilling rigs, not all of them have circulation or rotary systems.

They come in a variety of sizes. In general, servicing jobs require smaller rigs than workover jobs. The smallest rigs raise and lower a wireline or conductor line. Oilfield workers sometimes call these wireline rigs (fig. 6.1).

Figure 6.1. A small, light-duty unit

7

WELL SERVICING AND REPAIR

Wells require maintenance and repairs from time to time due to normal wear, age, and hazards of the environment to which the equipment is exposed. Downhole pumps, sucker rods, and gas-lift equipment all have moving parts, which wear out because of erosion from the fast-moving reservoir fluid, which may contain sand or particles of metal left from perforating, for example. Production tubing also corrodes. Both moving and stationary equipment can fail because of corrosion, scale, and paraffin deposits.

Lease operators are usually the first to notice abnormal conditions in the well that suggest the need for repair work. Routine tests and well reports on daily production, wellhead pressure, and percentage of water in the oil provide evidence of the need for maintenance or repair.

The most common service and repair jobs include swabbing and repairing or replacing sucker rod pumps, sucker rods, production tubing, and packers. (The next chapter describes another type of servicing job, fishing.)

REPAIRING BEAM PUMPING EQUIPMENT

Modern beam pumping units perform for a long time with proper care and when not overloaded. Proper care means regular lubrication of the moving parts and seasonal changes of the oil in the speed reducer. Many rig operators choose not to change the oil unless it appears to be dirty; however, they pull the drain plug on the speed reducer to drain any condensation.

Another maintenance check is to assure that the cranks are correctly counterbalanced. Improper weight can cause damage to the gear teeth.

Sucker Rods and Pumps

Sucker rods, their couplings, and sucker rod pumps can fail because of corrosion and scale, erosion and wear, careless handling, or stress from the pump's movement. Often, more than one of these factors is at work.

To service, repair, or replace the rods or pump, a crew pulls the sucker rod string out of the well. For a tubing pump crewmembers must also pull the tubing, and for an insert pump they pull only the sucker rod string.

8

FISHING

Oilfield workers have two names for pieces of metal lost or stuck in a well: *fish* and *junk*. A fish is a piece of equipment, pipe, or any other sizable piece of metal in the hole that should not be there. Junk is a smaller piece of metal, such as a broken bit tooth or a hand tool that a crewmember dropped in the well accidentally. Junk can interfere with workover or well service operations. When it does, the operation ceases, and crewmembers have to fish (remove) the junk from the well. Similarly, a large piece of equipment, part of the tubing string, or any other large fish impedes work and must be removed.

The operation to recover a fish or junk is a fishing job. Fishing often involves rotating a tool in the hole or circulation of a workover fluid, so it may require a larger service rig. However, many fishing operations can be done with wireline or coiled tubing run inside the production tubing.

TYPES OF FISH

Fish include drill pipe, drill collars, tubing, screen liners, packers, and sucker rods that are either stuck in the well or have broken off because of mechanical failure, corrosion, or abrasion.

Drill Pipe

Drill pipe or drill collars can get stuck in the hole for several reasons: (1) the hole can collapse around the pipe; (2) the pipe can get stuck in a keyseat, a small-diameter portion of the hole; or (3) pressure can hold the drill collars so securely to the wall of the hole that no amount of pulling can free the pipe.

The most common reason for the wall of the hole collapsing around the pipe is that, under certain conditions, salt water in pores of the rock can attract water in the drilling mud. If the formation consists of shale and the water in the mud is in contact with the water in the shale, the water in the mud has a tendency to transfer to the shale. Transferred water causes shale to expand; small sheets of shale then flake off into the hole, eventually fill it up, and the pipe sticks.

Pipe can also get stuck in a keyseat (fig. 8.1). A keyseat is caused by a dogleg, which is a severely crooked section of hole. ("It's as crooked as a dog's hind leg" is the expression that gives rise to the term.) The drill pipe tends to lean against the side of the dogleg and, as the pipe rotates, it digs out a new, smaller hole in the side of the main borehole.

9

SAND CLEANOUT AND WORKOVER

Workover jobs may include cleaning sand out of the well and adding a means of preventing sand from entering it, replacing liners, plugging the well, repairing casing, drilling deeper, and drilling around obstructions in the well. Some workover jobs require only a wireline to lower tools, but others need to rotate tubing or drill pipe, so the workover rig has equipment to rotate the pipe string. Operations that need to circulate workover fluid into the well require pumps and storage tanks.

SAND CLEANOUT

In a wire-wrapped screen completion, fine sand eventually infiltrates the gravel pack and the screen and fills up the inside of the slotted liner. Sometimes, however, in spite of every attempt to exclude it, sand enters the well and causes trouble. When this happens, a workover crew cleans the well out.

The method of cleaning out the sand depends on where the sand is and how tightly it is packed. All methods use circulation of a fluid, usually salt water, to flush the sand out.

Using a Macaroni Rig or Coiled Tubing

One method uses either a macaroni rig (fig. 9.1) or coiled tubing (fig. 9.2). A macaroni rig is a relatively small rig that handles special lightweight, small-diameter pipe called macaroni. The crew leaves the production tubing and packers in place and lowers the macaroni string or coiled tubing, generally about 1 to 1¼ inches (about 25–30 mm) in diameter, inside the production tubing. Crew members lower the string until it just reaches the top of the sand. Then they circulate salt water down the tubing at a high velocity, lowering the string as the sand washes out. This high-velocity salt water forces the sand to the surface through the annulus between the production tubing and the macaroni or coiled tubing.

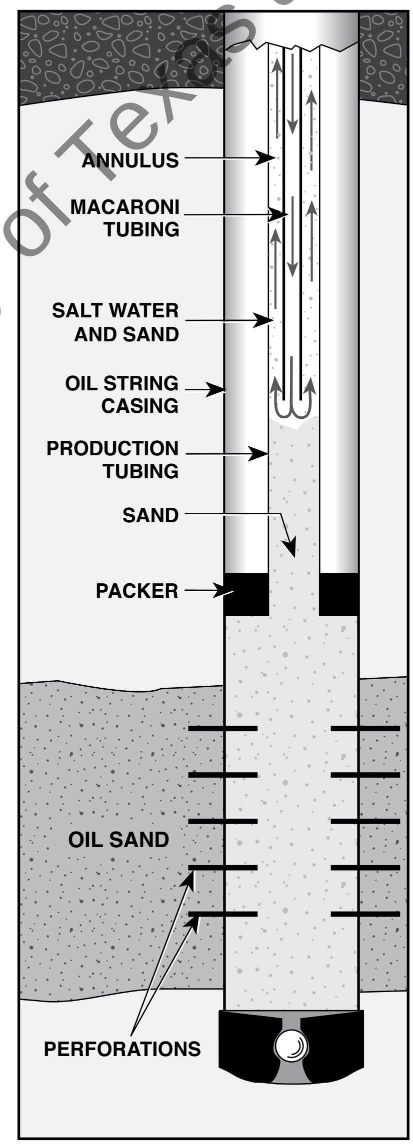

Figure 9.1. Macaroni tubing fits inside the production tubing to wash sand out.

10

WELL STIMULATION

Well stimulation includes techniques for overcoming the problem of a tight formation, or one that has a low permeability. Remember that permeability is a measure of how well the pores that contain hydrocarbons are connected to each other. Extracting the hydrocarbons from tight reservoirs is difficult and slow. On the other hand, the natural permeability of the rock may be adequate, but the formation near the wellbore may be damaged in a way that restricts the flow channels in porous rock. Formation damage can occur during drilling, completion, workover, production, or injection.

Low permeability, whether natural or artificial, reduces productivity to a rate that is not economical. Well stimulation is successful enough that many wells are stimulated immediately after completion and then whenever production drops because of low permeability.

Well stimulation overcomes low permeability by creating new flow channels or enlarging old ones. There are three ways to do this. The oldest method is to use explosives. During the 1930s, acid stimulation, or acidizing, became commercially available. Hydraulic fracturing, the third stimulation method, was introduced in 1948.

EXPLOSIVES

As early as the 1860s, crews exploded nitroglycerin inside wells to improve their productivity. They simply lowered a nitro charge into the open hole on a conductor line and detonated it to fracture the formation. Nitro shooting was fairly routine until the advent of acidizing and hydraulic fracturing.

For a time in the 1960s, lease operators experimented with nuclear explosives in a limited number of gas wells. While this method increased production somewhat, the cost was prohibitive.

Oil companies are still interested in explosive techniques because certain kinds of tight formations do not respond readily to either acidizing or hydraulic fracturing. Research continues in an effort to find other techniques that might increase production, but fracturing and acidizing are currently the most effective well stimulation methods.

11

ADDITIONAL RECOVERY TECHNIQUES

After a well has used up the reservoir's natural drives and all the hydrocarbons possible have been lifted by pumps or gas lift, statistics show that 25 to 95 percent of the oil in the reservoir may remain there. This amount of oil can be worth recovering if prices are high enough. The petroleum industry has developed several techniques to produce at least part of this remaining oil.

One thing to keep in mind about additional recovery techniques is that they are expensive and risky. They require special chemicals, equipment, and personnel. And there are no guarantees that a project will work. Of course, the potential rewards are high if a project does work out, but the risk is also high. In most cases, it takes years before a company actually starts recovering any oil from a project. Recovering oil from reservoirs beyond the initial production remains one of the great challenges facing the oil industry.

WATERFLOODING

When the wells drilled into one reservoir stop flowing, the company representative may hire a workover contractor to pump, or inject, water into some of them (fig. 11.1). The wells into which water is pumped become injection wells. This water kills the wells and then sweeps into the reservoir and moves some of the oil that remains in the rock toward other wells in the same reservoir. These producing wells then pump up the oil and water, often by means of a beam pumping unit. Several injection wells surround each producing well. This procedure is called waterflooding.

Sometimes a crew injects a gas, such as natural gas, nitrogen, or flue gas, in alternating steps with water to improve recovery. In this case it is called gas injection.

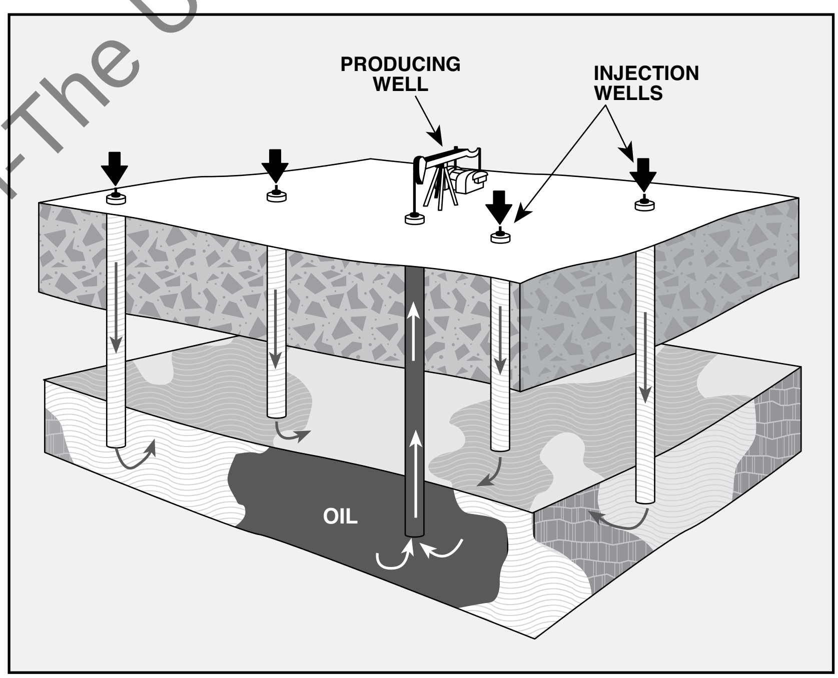

Figure 11.1. In waterflooding, water is injected into wells around the producing well. This is a five-spot pattern—four injection wells and one producer—but many other patterns can be used.

12

CONCLUSION

The tens of thousands of wells producing all over the world cannot begin to produce or continue to do so efficiently without the efforts of completion, well servicing, and workover personnel. Using sophisticated techniques and equipment, these people start and keep oil and gas flowing, from tiny 10-barrel-a-day "stripper wells" to giant gas wells producing millions of cubic feet (cubic metres) of gas each day.

Whether using a simple truck-mounted swabbing unit or a complicated jackup offshore unit, well service and workover companies the world over keep one of our most vital resources—petroleum—available to us when and where we need it.

To obtain additional training materials, contact:

PETEX
THE UNIVERSITY OF TEXAS AT AUSTIN
PETROLEUM EXTENSION SERVICE
1 University Station, R8100
Austin, TX 78712-1100

Telephone: 512-471-5940
or 800-687-4132
FAX: 512-471-9410
or 800-687-7839
E-mail: petex@www.utexas.edu
or visit our Web site: www.utexas.edu/ce/petex

To obtain information about training courses, contact:

PETEX
LEARNING AND ASSESSMENT CENTER
THE UNIVERSITY OF TEXAS
4702 N. Sam Houston Parkway West, Suite 800
Houston, TX 77086

Telephone: 281-397-2440
or 800-687-7052
FAX: 281-397-2441
E-mail: plach@www.utexas.edu
or visit our Web site: www.utexas.edu/ce/petex

ISBN 0-88698-175-1
9 780886 981754

3.60110
ISBN 0-88698-175-1