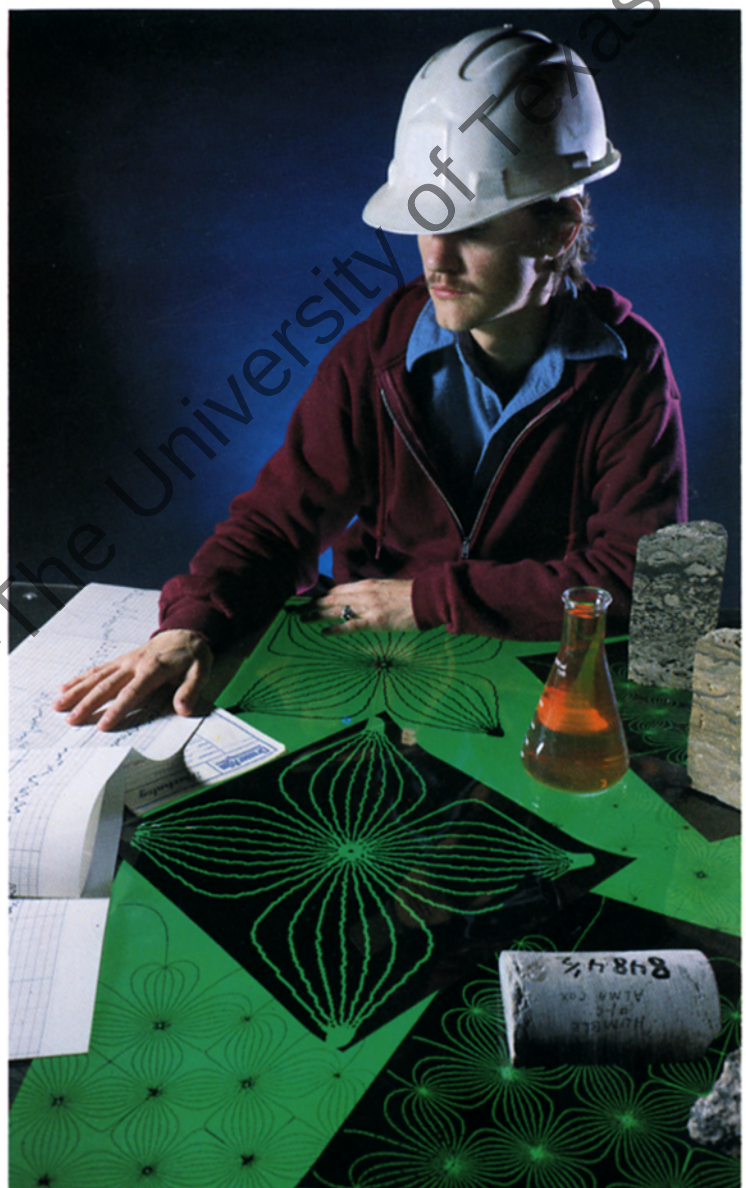
Improved Recovery

OIL AND GAS PRODUCTION



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How to Use This Manual

The format of this manual includes a set of specific objectives for each section; at the end of the section is a competency self-test. To get maximum benefit from the manual, read the specific objectives carefully before studying the material in each section. The self-test is based on the objectives. As you study the material in the section, take notes, using the objectives as a guide to the most important parts.

When you feel that you have mastered the objectives, begin the self-test. Since it is a self-test, *you* must decide whether you should refer back to the material to answer the questions by determining how important that section is to your work. If you feel that you need to be very competent in an area, do not refer back until you have finished the test. This way, using the scoring points given at the beginning of the test, you can determine your percentage of competency. Score the test by using the corresponding key provided at the end of the manual.

Introduction

Immense quantities of known oil remain untapped in the United States. Of the 460 billion barrels of oil discovered before the early 1980s, government and industry studies estimate that just over one-fourth has been produced (fig. 1). Of the remaining 339 billion barrels, only 27 billion can be recovered by conventional primary and secondary recovery methods. Recovery efficiencies in U.S. oil fields average about 19 percent for primary recovery and about 14 percent for secondary recovery.

Various methods have been developed to recover part of the residual oil. They are often referred to as *enhanced oil recovery* (EOR). However, the difference of opinion about the precise meaning of this term can lead to confusion when it is used. Therefore, this manual will refer to methods of recovering residual oil as *improved recovery.*

Waterflooding has been the main type of improved recovery for several decades. Fields that respond well to waterflooding may yield much greater percentages than the 14 percent average for secondary recovery. However, even reservoirs that perform best under waterflooding leave behind a sizable portion of oil. Moreover, nearly all the candidates have already been identified and are being waterflooded. One study predicts that conventional secondary production in known fields will decline from 50 percent of U.S. production in 1980 to below 10 percent by 1995. The same study expects that the use of advanced recovery methods such as chemical flooding, miscible gas injection, and steam drive will then account for over 75 percent of U.S. production, excluding Alaska.

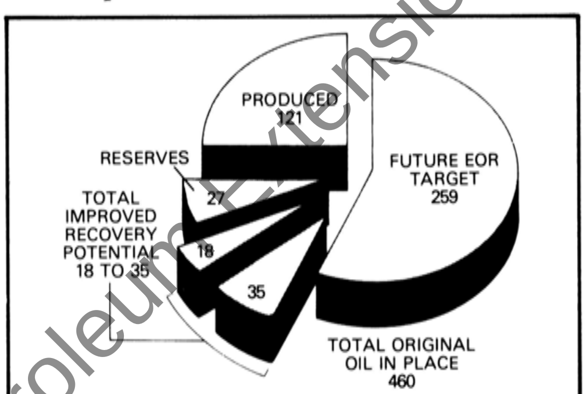

Figure 1. Domestic oil resources available for improved recovery, in billions of barrels. (Reprinted with the permission of *Well Servicing* and the Association of Oilwell Servicing Contractors)

The government estimates that advanced methods, in their current state of development, can recover up to another 50 billion barrels. The remaining 250 billion barrels are a target for recovery by future technologies. A comparison may help convey the magnitude of 50 billion barrels of oil; this quantity is roughly equal to five new Alaskan oil fields the size of Prudhoe Bay or one-third of Saudi Arabia's oil reserves.

In the 1980s, the oil industry is undergoing a transition from primary reliance on waterflooding to the increasing use of advanced recovery methods. These methods are more expensive than waterflooding. They use injection fluids and heat that are more costly than water. They often require specialized production equipment. And they incur high capital costs due to long delays between the initial investment and the sale of the produced oil. The cost effectiveness of using these methods depends on a complex interplay of economics, government policy, and technological advancement. In mid-1980, the cost of recovering 1 barrel of oil by these methods ranged from–

$22 to $46 for chemical flooding;

1

Petroleum Reservoirs

OBJECTIVES

Upon completion of this section, the student will be able to:

1. Identify and define three characteristics of reservoirs.
2. Identify two main types of rock found in reservoirs, and describe factors that influence their permeability and porosity.
3. Identify and define types of traps.
4. Describe the contents of reservoirs and the natural pressures operating in them.
5. Identify methods of evaluating reservoirs for improved recovery projects and the data they provide.
6. Describe ways data are organized to gain a complete description of reservoir structures and fluids.

2

Production Energies in Oil Recovery

OBJECTIVES

Upon completion of this section, the student will be able to:

1. Define *reservoir drive mechanism*, identify four drive mechanisms, explain how they work, and compare their effectiveness in recovering oil.
2. Define *artificial lift*, identify four methods of this type, and explain how they work.
3. Define *well stimulation*, identify two methods of this type, and explain how they work.
4. Define *improved recovery*, and identify the four major types.
5. Give two alternate meanings for each of the terms, *secondary recovery*, *tertiary recovery*, and *enhanced oil recovery*.

3

Waterflooding

OBJECTIVES

Upon completion of this section, the student will be able to:

1. Define *waterflooding* and list its advantages and disadvantages.
2. Describe three forces that determine the behavior of liquids in reservoirs: wetting, surface tension, and capillarity.
3. Define *displacement efficiency* and explain how it is affected by capillarity.
4. Define *sweep efficiency* and explain how it is affected by mobility ratio, reservoir heterogeneities, and gravity segregation.
5. List the three factors that are taken into account in predicting the amount of oil that will be recovered from a waterflood.

4
Chemical Flooding

OBJECTIVES

Upon completion of this section, the student will be able to:

1. Define *polymer* and list three properties of polymers that are useful for improved recovery.
2. List the uses and the disadvantages of polymer solutions in improved recovery.
3. Define *micelle* and list the components of a micellar solution.
4. Identify the properties of a microemulsion and describe the process by which a microemulsion displaces oil from rock pores.
5. Describe the steps of a micellar-polymer flood.
6. Identify the reservoir conditions required for successful use of a micellar-polymer flood.
7. List the advantages and the disadvantages of micellar-polymer flooding.
8. Define *alkaline flooding* and identify four mechanisms by which alkaline solutions are believed to displace oil from rock pores.
9. Explain why alkaline flooding is a little-used improved recovery method.
10. Compare micellar-polymer flooding with other improved recovery methods in terms of production cost and recovery efficiency.

5

Carbon Dioxide Flooding

OBJECTIVES

Upon completion of this section, the student will be able to:

1. Compare the use of carbon dioxide with that of other injection gases in terms of cost and recovery efficiency.
2. Describe the process of multiple-contact miscibility by which carbon dioxide displaces reservoir oil.
3. Define *miscibility pressure* and list three factors that influence it.
4. Explain how carbon dioxide works to displace oil immiscibly.
5. Identify the factors that can cause poor sweep efficiency during a carbon dioxide flood.
6. Identify the reservoir conditions favoring and hindering successful use of carbon dioxide flooding.
7. List three reasons why the West Texas area is particularly suited for the use of carbon dioxide flooding.

6

Thermal Recovery

OBJECTIVES

Upon completion of this section, the student will be able to:

1. Define *thermal recovery* and describe its main use in improved recovery.
2. Explain the displacement process and mechanisms of steam drive.
3. Identify the reservoir conditions necessary for successful steam drive.
4. Define *oil-steam ratio* and explain the importance of this ratio in determining the profitability of a steam-drive project.
5. Define *steam soak* and explain the process and the displacement mechanism.
6. Define *forward in situ combustion,* identify the zones created in the reservoir during this type of combustion, and explain the displacement mechanisms occurring in each zone.
7. Identify factors that affect the amount of coke deposited, the rate of combustion, and the amount of heat loss during in situ combustion.
8. Define *wet in situ combustion* and list the advantages of this method.
9. Compare steam drive with in situ combustion in terms of recovery efficiency, production problems, and future use.

To obtain additional training materials, contact:

PETEX
THE UNIVERSITY OF TEXAS AT AUSTIN
PETROLEUM EXTENSION SERVICE
J.J. Pickle Research Campus
10100 Burnet Road, Bldg. 2
Austin, TX 78758

Telephone: 512-471-5940
or 800-687-4132
FAX: 512-471-9410
or 800-687-7839
E-mail: petex@www.utexas.edu
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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
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