UNIT III
RESERVOIR ENGINEERING

In this unit, you will:

- learn and practice vocabulary related to reservoir engineering
- revise grammar: Participles, Absolute Participle Construction
- read about working tools of reservoir engineers and the concept of integrated study

INTRODUCTION

I. *Read the text and answer the question below.*

In recent decades the price of crude oil has been fluctuating severely. Therefore, oil companies have had to cut their costs and put more effort into estimating as accurately as possible the economics of projects and associated risks. Technical advances in well design and drilling now allow the drilling of horizontal wells several kilometres long, as well as multilateral wells. Such wells make it possible to develop the fields using less wellheads and consequently more convenient surface infrastructures. Also, new types of structures have replaced traditional platforms, allowing a reduction in capital costs and also increasing the possibility of deep offshore development. While drilling fewer but longer wells allowed for a significant cost reduction, the technical risk involved in such operations is higher. These complex wells are more expensive than normal vertical wells and whenever there is a failure, the impact on the economics of the project is significant. Furthermore, such wells are prone to technical problems in the drilling phase, and also running logging tools is often quite a sophisticated process. So, even more than in the past it is extremely important to carefully plan the strategy of reservoir development.

- *Why is planning the reservoir development strategy so important today?*

II. *Say these words out loud. Which syllable is stressed? Put the words in the columns below.*
liquid / reservoir / occurrence / objective / accurate / balance / expertise / guarantee / technique / modeling / analogue / discipline / increase (*n.*) / increase (*v.*) / data / strategy / integrate / economics / identify / physics / physical / conventional / pressure / estimate / basis / basic / financial / generation/ parallel / numerical / coherence / process / resource / control / reserve / impact / influence / technology / analysis / analyse / complex

●•	•●	●••	•●•	••●	●•••	•●••	••●•

III. *Work in pairs to translate the words and word combinations.*
to test химия **occurrence** поверхность **to recover (oil and gas)** истощение, выработанность (пласта) **phase** идентифицировать, выявлять **liquid** физика **conventional** инструмент **subsurface** давление **evaluation** точный **workover** стоимость **financial** физический **fluid** аналог **application** анализ **data**

IV. *Match A and B.*

1.

A	B
1. manner	a. выбор, отбор
2. number / numerical	b. цель
3. optimal	c. число, количество / численный, количественный
4. selection	d. прикладной
5. to guarantee	e. интегрировать, объединять
6. to initiate / initial	f. способ, метод
7. applied	g. связность, когерентность, целостность
8. objective	h. оптимальный; наилучший
9. to integrate	i. начинать, предпринимать, приступать / первоначальный; исходный; отправной
10. coherence	j. гарантировать

2.

A	B
1. test	a. коэффициент; фактор
2. expertise	b. сотрудничество
3. correlation	c. генерировать, производить, создавать
4. cooperation	d. стратегия, методика
5. to generate	e. аналог
6. strategy	f. соотношение, взаимосвязь, сопоставление, корреляция
7. hypothesis	g. опыт, знания
8. analogue	h. гипотеза
9. factor	i. основа
10. basis	j. исследование, проверка, испытание

V. *Read the word combinations below. What do they mean?*

reservoir engineering, number and type of wells to drill, reservoir development strategy, selection of completion process and equipment, liquid phase of crude oil, oil or gas-bearing reservoir, injected fluid, reserve estimates, numerical reservoir modeling, physical properties, correct prediction, surface structure design, economics of the project, reservoir studies, to consider economic factors, reservoir system, subsurface geology, working tools, each individual reservoir, conventional techniques, the basic laws of physics and chemistry, applied mathematics, formation evaluation, workover planning, production forecasting, in the most effective manner, technical expertise, successful application, simulation modeling, optimal development plans for oil and gas reservoirs, cooperation of various specialists, on the basis of, cost increase

VI. *Use a dictionary or any search engine to finish the sentences.*

1. Oil or gas-bearing reservoirs are ________________________________.
2. Subsurface geology is ____.
3. Formation evaluation is _______________________________________.
4. A reservoir system is ____.
5. Numerical reservoir modeling is ________________________________.

VII. *Make sure you pronounce the words which end in **-gue** properly. Note the difference in spelling between British and American equivalents.*

analogue (BrE) - analog (AmE)
catalogue (BrE) - catalog (AmE)
dialogue (BrE) - dialog (AmE)
monologue (BrE) - monolog (AmE)

WORD FORMATION

- *Fill in the gaps.*

to work - ____________	work - работа
to study - изучать	study - ____________
to change - ____________	change - перемена, изменение
to practice - практиковать, тренировать	practice - ____________
to plan - план	plan - ____________
to use /juːz/ - ____________	use /juːs/ - использование
to risk - рисковать	risk - ____________
to place - ____________	place - место
to limit - ____________	limit – предел, лимит
to inʹcrease - ____________	ʹincrease – увеличение, возрасатание
to model - моделировать	model - ____________
to design - проектировать, конструировать	design - конструкция
to ʹforecast - прогнозировать, предсказывать	ʹforecast - ____________
to seep - просачиваться	seep - ____________
to flow - ____________	flow – течение, поток
to pump - ____________	pump - насос
to conʹtrol - ____________	conʹtrol - управление, руководство, контроль
to map - ____________	map - карта (напр., географическая)
to estimate /ˈestɪmeɪt/ - оценивать, подсчитывать (предварительно)	estimate /ˈestɪmət/ - ____________
to ʹinfluence - влиять	ʹinfluence - ____________
to ʹimpact - ____________	ʹimpact - воздействие; удар, толчок
to drop - ____________	drop - понижение, спад
to delay – задерживать, откладывать	delay - ____________

- *Nouns which end in* ***-is*** *usually come from Greek. Their plurals are made by changing* ***-is*** *to* ***-es****. Make the plural of the words below.*

analys**is** - analys**es**
thesis -
hypothesis -
crisis -
basis –

- *Form nouns according to the given patterns and translate them into Russian:*

active активный+ **ty** = activity активность viscous вязкий + **ity** = viscosity вязкость

able	способный	+ **ty** = ability ____________
applicable	________	+ **ty** = ________________
capable	________	________________
damageable	________	________________
dense	________	________________
drillable	________	________________
effective	________	________________
exchangeable	________	________________
feasible	________	________________
flexible	________	________________
fluid	________	________________
human	________	________________
hydroelectric	________	________________
immovable	________	________________
impermeable	________	________________
manageable	________	________________
movable	________	________________
penetrable	________	________________
probable	________	________________
productive	________	________________
recoverable	________	________________
safe	________	________________
scarce	________	________________
viable	________	________________

- *Complete the table by filling in the missing parts of speech (there may be more than one variant form).*

Verb	**Noun**	**Adjective**
		producing producible
	driller drilling drillability	

esimate		X
		reducible
	increase	
rotate		
	recovery recoverability	
		integrated

GRAMMAR REVISION

I. *Use the words in brackets to make sentences with the Participles.*

1. While oil spills from ships and offshore platforms are the most well-known source of oil in ocean water, a lot of oil actually gets into water from natural oil seeps ______________ from the ocean floor. (come)
2. A reservoir is a porous and permeable underground formation ______________ a natural accumulation of producible hydrocarbons (oil and/or gas) which is ______________ by impermeable rock and/or water barriers and is ______________ by a single natural pressure system. (contain, confine, characterize)
3. If reserve estimates contained no risk, no dry holes would be ______________. (drill)
4. The term '______________ reserves' refers to the ______________ volume of reserves and not just to the productivity of the well or reservoir. (prove, estimate)
5. One of the two major objectives of economic evaluation is estimation of the economic value of the ______________ future production. (predict)
6. The primary purpose of heat injection ______________ steam or hot water is to transfer heat from the ______________ fluid to the crude oil and reservoir rocks to reduce oil viscosity. (use, inject)
7. Midstream oil and gas is a major phase of oil and gas industry operations ______________ the transportation, storage, and wholesale marketing of the products. The midstream segment is different from upstream and downstream segments of oil and gas industry because there is considerably low risk. (involve)

II. *Translate the sentences into Russian paying attention to Absolute Participle Construction.*

1. Exploration wells usually being drilled in remote locations where little or no previous subsurface engineering experience is available, the skills of the exploration geologist are extremely important for successful drilling.
2. With inspection of drilling, production, and workover equipment having to be made on a regular basis, on-the-job shutdown maintenance should be carried out at 90 to 120-day intervals.
3. Environmental factors such as the nature of the formation to be drilled, hole depth and direction, characteristics of drilling fluids, and the way in which a drill rig is operated

being of critical importance to bit performance and design, engineers consider these factors for all designs, and every design begins with close cooperation between the designer and the drilling company.

4. Formation evaluation techniques determine whether a well can be completed for commercial production, these methods also determining certain characteristics of potentially productive rock formations to indicate the most useful method of well completion.
5. Reservoir oil may be saturated with gas, the degree of saturation being a function, among others, of reservoir pressure and temperature.
6. Reserves are placed into one of two principal classifications, either proved or unproved. Unproved reserves are less certain to be recovered than proved reserves and may be further subclassified as probable and possible reserves. Proved reserves are categorized as proved developed producing (PDP), proved developed nonproducing (PDNP), and proved undeveloped (PUD), with the latter two categories deriving, in part, from the scale of expected investment necessary to obtain the production.

- *Now, paraphrase the sentences without using Absolute Participle Construction. You may use conjunctions* ***because, since, as*** *or others. Remember that Absolute Participle Construction is mostly used in writing.*
  e.g. With inspection of drilling, production, and workover equipment having to be made on a regular basis, on-the-job shutdown maintenance should be carried out at 90 to 120-day intervals. – <u>Since</u> inspection of drilling, production, and workover equipment has to be made on a regular basis, on-the-job shutdown maintenance should be carried out at 90 to 120-day intervals.

READING

- *Study the word list and translate the example sentences in writing.*

1. **essential** *adj*. очень важный, существенный
   Permeability is one of the ***essential*** *properties used in evaluation of a potentially producing formation. Unfortunately there are no logging devices that read permeability because it is a dynamic property.* ____
   ____
   ____

2. **performance** *n.* эксплуатационные показатели (напр., месторождения)
   Numerical reservoir simulation, also known as reservoir simulation, is a process performed in order to estimate the ***performance*** *of a reservoir in real time i.e., when a well is drilled and production starts.*____
   ____
   ____

3. **bounds** *n.* ограничения
   wc **within the bounds of** в пределах, в рамках
4. **to govern** *v.* управлять; обусловливать, определять
5. **economical** *adj.* экономичный, экономный

*The main reason for using a bit is that it saves money on a cost-per-foot basis. To be **economical**, an expensive bit must make up for its additional cost by either drilling faster or staying in the hole longer.* ____

____

____

*Reserves are not simply a physical volume but an **economically** recoverable volume.*

____

cf. **economic** экономический; рентабельный

wc **economic modeling** экономическое моделирование

6. **to define** *v.* устанавливать, очерчивать, определять

*There may be problems if responsibilities of the team members are not adequately **defined**.* ____

*The terms "resources" and "reserves" are relatively easy to **define**.* ________________

____

definition *n.* определение

7. **sufficient** *adj.* достаточный

*When a reservoir lacks **sufficient** pressure for producing oil and gas from the wells, artificial lifting methods are employed.* ____

____

8. **to supplement** *v.* дополнять, добавлять, восполнять
9. **vapour** *n.* пар
10. **transient** *n.* неустановившийся режим, переходное состояние

pressure transient analysis интерпретация КВД (кривых восстановления давления)

***Pressure transient analysis**, also known as pressure transient well test, is an assessment test carried out to determine the performance of a wellbore by measuring the pressure and flow rate in the wellbore. The tests are performed at various stages of the well, i.e., at the time of drilling, completion of process and production phase.* _________________

____

____

____

____

11. **material balance** материальный баланс

*The **material balance** is an application of conservation of mass to the analysis of physical systems.* ____

12. **volumetric** *adj.* объемный; волюметрический

wc **volumetric method** объемный метод подсчета запасов

***Volumetric methods** attempt to determine the amount of oil and/or gas-in-place[1] and reserves by calculating a volume from the physical properties of the reservoir(s). The*

[1] in place – на месте залегания, пластовый
Oil-In-Place (OIP): the oil in place at any time in the reservoir. The original oil in place is OOIP. Gas-In-Place (GIP): the original amount of gas in the reservoir before production.

*method requires knowledge of the size of the reservoir, and the physical properties of the reservoir rock(s) and fluid(s).*____

____

____

____

13. **well testing** опробование; испытание; освоение скважины
*Only **well testing** provides information on the dynamic behavior of a reservoir.* ________

____

14. **PVT (Pressure-Volume-Temperature)** соотношение давления, объема и температуры
wc **PVT analysis** PVT анализ
***PVT analysis** is the determination of the characteristics and behavior of reservoir fluids under various conditions such as pressure, volumes, and temperature. The primary objectives of the study are to estimate the volume of crude oil and gas, to calculate the flow properties of reservoir fluids, to optimize the liquid recovery and to provide details about the pressure maintenance.* ____

____

____

____

15. **regulatory** *adj.* контролирующий, регулирующий
wc **regulatory body/authority** контролирующая организация
16. **issue** *n.* острая проблема, вопрос
17. **feedback** *n.* ответная реакция, обратная связь, взаимодействие
*When using the logging tool, long cables are required to be dropped into the wellbore to get continuous **feedback** and measurements such as density and electrical conductivity.*

____

____

18. **to suspect** *v.* предполагать, догадываться, подозревать
19. **sealing fault** непроводящий, запечатывающий сброс (сдвиг)
20. **consistent** *adj.* сообразный; последовательный
to be consistent with smth. согласовываться, не противоречить
21. **execution** *n.* реализация, выполнение, исполнение
to execute *v.* выполнять, осуществлять
22. **to cross-check** *v.* перепроверять, используя другие методы; выполнять перекрестную проверку
***Cross-check** your answers with a calculator.*______________________________________
23. **simultaneously** *adv.* одновременно
*A top drive can **simultaneously** withstand loads of up to 1 million pounds (the capacity can be even more) with pressure of up to 5000 psi[2] and rotate the drill string up to 200 or beyond rpm[3].* ____

____

____

[2] pounds/sq. inch - фунт на квадратный дюйм
[3] revolutions per minute - оборотов в минуту (об/мин)

- *Find in Text IIIA the English equivalents of the following:*

коэффициент извлечения нефти (КИН)	____________________
наиболее эффективно и экономично	____________________
получить оптимальную прибыль	____________________
жидкая и паровая фазы	____________________
производить точную оценку запасов	____________________
интерпретация геологических и/или технических данных	____________________
финансовая отчетность	____________________
качество и количество имеющихся данных	____________________
комплексное исследование	____________________
выполнять разные задачи параллельно	____________________
благодаря постоянному сотрудничеству членов команды	____________________
нехватка имеющихся данных	____________________
на всех стадиях исследования	____________________

TEXT IIIA

1. Nowadays even more than in the past it becomes essential to carefully plan the strategy of reservoir development in terms of number and type of wells to drill, the selection of completion process and equipment as well as the recovery process (depletion, injection, etc.). These choices, together with a correct prediction of the field performance, will impact heavily on the surface structure design and thus the economics of the project. To stay within fixed economic bounds and minimize risk, oil companies make use of reservoir studies. While such studies have always been performed, today they have to be more accurate and less expensive. The branch of petroleum engineering which deals with such studies is called reservoir engineering.
2. Reservoir engineering covers a wide variety of subjects including the occurrence of fluids in an oil- or gas-bearing reservoir, movement of those or injected fluids, and evaluation of the factors governing the recovery of oil and gas. The main objective of reservoir studies is to maximize oil production and oil recoverability factor, to ultimately recover oil and gas from reservoirs in the most effective and economical manner.
3. To obtain optimal profit from a field the engineer or the engineering team must identify and define all individual reservoirs and their physical properties, determine each reservoir's performance, prevent drilling of unnecessary wells, and consider all important economic factors, including income taxes. Early and accurate identification and definition of the reservoir system is essential to effective engineering. Conventional geologic techniques seldom providing sufficient data to identify and define each individual reservoir, the engineer must supplement the geologic study with engineering data and tests to provide the necessary information.
4. The working tools of the reservoir engineer are subsurface geology, applied mathematics, and the basic laws of physics and chemistry governing the behaviour of liquid and vapour phases of crude oil, natural gas, and water in reservoir rock. To determine optimal development plans for oil and gas reservoirs reservoir engineers are involved in formation evaluation, pressure transient analysis of oil and gas wells, material balance and volumetric analysis, production forecasting,

well testing, well drilling and workover planning, economic modeling, and PVT analysis of reservoir fluids. They also carry out numerical reservoir modeling, or simulation modeling, which has been practiced since the beginning of the 1960s. Of particular interest to reservoir engineers is generating accurate reserve estimates which are based on interpretation of geologic and/or engineering data available at the time of the appraisal, the estimates being used in financial reporting to regulatory bodies.

5. In reservoir engineering the cooperation of various specialists and the concept of integrated study are the main issue. The importance of integration is related to the scarcity of the available data, that must be supplemented through hypotheses, analogues and correlations. Putting a geophysicist, a geologist and a reservoir engineer in the same working room is favourable to the generation of team work, because the study is divided in tasks that are not independent, the results of each task representing the feedback for the others. For example, the reservoir engineer may suspect the presence of a sealing fault on the basis of pressure transient analysis data, but this must be consistent with the geological scheme. If different specialists coordinate their work there will be no cost increase or delay in the project execution. It is therefore necessary that each specialist, before initiating a new task, cross-check the coherence of the study with the other disciplines, since all the tasks should be performed, as much as possible, simultaneously.

- *Read Text III A again and do COMPREHENSION exercises below.*

COMPREHENSION

I. *Give each part of the text a heading.*

Part 1 ___________________
Part 2 ___________________
Part 3 ___________________
Part 4 ___________________
Part 5 ___________________

II. *Answer the questions.*

1. What is reservoir engineering?
2. Why are oil companies interested in reservoir studies?
3. What is the main objective of reservoir studies?
4. What are the working tools of reservoir engineers?
5. What does PVT stand for?
6. What is simulation modeling?
7. What is of particular interest to reservoir engineers? Why?
8. Why is integration essential to effective reservoir studies?
9. What should be done to avoid a delay in the project execution?

III. *Say whether the statements below are true, false or not mentioned in the text.*

1. Today it is not essential to plan the reservoir development strategy.
2. The economics of oil and gas projects is only impacted by a correct prediction of the field performance.

3. Oil companies are interested in reservoir studies to drill more wells.
4. Reservoir studies were not performed in the 20th century.
5. Conventional geologic techniques provide sufficient data for reservoir studies.
6. Methods of applied mathematics are not used by reservoir engineers.
7. The concept of integrated study involves cooperation of geologists, geophysicists, drilling engineers and production engineers.
8. Cooperation of different specialists guarantees coherence of the resulting study.
9. To manage different tasks simultaneously is quite easy.

VOCABULARY

I. *Find in the vocabulary to Text IIIA the words which mean:*

– to do a piece of work, perform a duty, or put a plan into action
– how well or badly you do something; how well or badly something works
– in agreement with something
– to have an idea that something is probably true or likely to happen, especially something bad, but without having definite proof
– to prove that something is true

II. *Match a word and its meaning:*

1. sufficient	a. expert knowledge or skill in a particular subject, activity or job
2. essential	b. to make sure that information, figures, etc. are correct by using a different method or system to check them
3. feedback	c. extremely important in a particular situation or for a particular activity
4. to govern	d. enough for a particular purpose; as much as you need
5. simultaneously	e. a period of time when somebody/something has to wait because of a problem that makes something slow or late
6. income tax	f. advice, criticism or information about how good or useful something or somebody’s work is
7. to cross-check	g. at the same time as something else
8. delay	h. to control or influence somebody/something or how something happens, functions, etc.
9. expertise	i. the amount of money that you pay to the government according to how much you earn

III. *Reproduce the situations in which the words from ex. I and II are used in the text.*

IV. *Fill in the gaps with the words from the box:*

performance (x2) PVT revised regulatory (x2) defines
coherence sufficient essential volumetric expertise vapour

1. It is difficult to find staff with the level of ___________ required for this job.
2. The facility is shut down while ___________ repairs are being carried out.
3. The company's ___________ was impacted by the high value of the pound.
4. An untapped reservoir may be under ___________ pressure to push hydrocarbons to the surface.
5. At such temperatures and pressures the substance may exist as a single phase (solid, liquid, or ___________) or as a two-phase system.
6. The estimation of producible volumes for gas reservoirs is less complex than for oil reservoirs, because the fluid dynamics are simpler and similar field ___________ is more directly applicable. The basic principles of ___________ gas-in-place and recovery factor are the same as for crude oil.
7. Much effort has been put into achieving ___________ within the team.
8. In most situations, reservoirs are classified as oil reservoirs or as gas reservoirs by a ___________ body. In the absence of a ___________ body, the classification is based on the natural occurrence of the hydrocarbon in the reservoir as determined by the operator.
9. Reserve estimates are based on interpretation of geologic and/or engineering data available at the time of the estimate and they generally will be ___________ as reservoirs are produced, as additional geologic and/or engineering data become available, or as economic conditions change.
10. Laboratory ___________ analysis of the reservoir fluid ___________ the change in volume per unit pressure drop.

V. *Find in **B** synonyms to the words in **A**.*

A	***B***
1. selection	a. in parallel
2. issue	b. evaluation
3. to predict	c. limits
4. to supplement	d. problem
5. simultaneously	e. to forecast
6. objective	f. to influence
7. bounds	g. to add
8. to impact	h. purpose
9. appraisal	i. number
10. quantity	j. choice

VI. *Find in **B** antonyms to the words in **A**.*

A	***B***
1. to prevent	a. the former
2. to initiate	b. scarce
3. correct	c. unimportant
4. essential	d. to allow

5. the latter	e. to finish
6. sufficient	f. worst
7. delay	g. to destroy
8. abundance	h. wrong
9. optimal	i. advance
10. to generate	j. scarcity

TEXT IIIB

- *Translate the text into Russian and do the exercise below.*

Oil and Gas Recovery Methods

Extracting oil and natural gas from deposits deep underground is not as simple as just drilling and completing a well. Any number of factors in the underground environment – including the porosity of the rock and the viscosity of the deposit – can impede the free flow of product into the well. In the past, it was common to recover as little as 10 percent of the available oil in a reservoir, leaving the rest underground because the technology did not exist to bring the rest to the surface. Today, advanced technology allows production of about 60 percent of the available resources from a formation.

Primary recovery refers to the recovery of oil and/or gas that is recovered by either natural flow or artificial lift through a single wellbore, i.e., when the pressure falls, artificial lift technologies, such as pumps, are used help bring more fluids to the surface. In some situations, natural gas is pumped back down the well underneath the oil. The gas expands, pushing the oil to the surface. Gas lift technology is often used in offshore facilities. Thus, primary recovery occurs as a result of the energy initially present in the reservoir at the time of discovery. Primary recovery often taps only 10 percent of the oil in a deposit. When the initial energy has been depleted and the rate of oil recovery declines, oil production can be increased by the injection of secondary energy into the reservoir.

Secondary recovery is the recovery of oil and/or gas that involves the introduction of artificial energy into the reservoir via one wellbore and production of oil and/or gas from another wellbore. Conventional means of secondary recovery include the immiscible processes of water flooding and gas injection. Currently in the United States, waterflooding is the dominant secondary recovery method in that about half of the oil production is recovered from waterflood projects. This can bring an additional 20 percent of the oil in place to the surface.

After secondary recovery, a significant amount of oil may remain, and attempts to recover oil beyond primary and secondary recovery are referred to as **tertiary recovery**. Any method that recovers oil more effectively than plain waterflooding or gas injection is defined as **enhanced recovery** (EOR). The more sophisticated enhanced methods may be initiated as a tertiary process if they follow water flooding or gas injection, or they may be a secondary process if they follow primary recovery directly. Many of the enhanced recovery projects are implemented after waterflooding.

So, enhanced recovery techniques are used to mobilize the remaining oil. There are three common approaches: thermal recovery, gas injection or chemical flooding. Enhanced recovery techniques are employed to bring as much as 60 percent of the reserve to the surface.

Chemical flooding, or chemical oil recovery, involves mixing dense, water-soluble polymers with water and injecting the mixture into the field. The water pushes the oil out of the formation and into the well bore.

Gas injection uses either miscible or immiscible gases. Miscible gasses dissolve CO2, propane, methane or other gasses in the oil to lower its viscosity and increase flow. Immiscible gasses do not mix with the oil, but increase pressure in the "gas cap" in a reservoir to drive additional oil to the well bore.

Thermal recovery is related to injecting steam into the formation. The heat from the steam makes the oil flow more easily, and the increased pressure forces it to the surface.

***Which recovery method**:*

uses polymers? ________________________________

relies on natural flow? ________________________________

uses gases? ________________________________

uses steam injection? ________________________________

is the least effective? ________________________________

employs artificial lift technologies? ________________________________

is dominant in the US? ________________________________

TEXT IIIC

- *Fill in the missing parts of the text.*

	To describe the subsurface flow processes mathematically,
	by increasing the recovery from a given reservoir.
	we would not be able to run simulations that exploit all available information,
	have been popular for many years
	one cannot generally expect to run simulations directly on geological models in the foreseeable future.
A	an important tool for qualitative and quantitative prediction of the flow of fluid phases.

Reservoir Simulation

Reservoir simulation is the means by which we use a numerical model of the petrophysical characteristics of a hydrocarbon reservoir to analyze and predict fluid behavior in the reservoir over time. Simulation of petroleum reservoirs started in the mid 1950's and has become ____________________**A**____________________ Reservoir simulation is a complement to field observations, pilot field and laboratory tests, well testing and analytical models and is used to estimate production characteristics, calibrate reservoir parameters, visualize reservoir flow patterns, etc.

The main purpose of simulation is to provide an information database that can help the oil companies to position and manage wells and well trajectories to maximize the oil and gas recovery. Generally, the value of simulation studies depends on what kind of extra monetary or other profit they will lead to, e.g., ____________________**B**____________________ However, even though reservoir simulation can be an invaluable tool to enhance oil-recovery, the demand for simulation studies depends on many factors. For instance, petroleum fields vary in size from small pockets of hydrocarbon that may be buried just a few meters beneath the surface of the earth and can easily be produced, to huge reservoirs stretching out several square kilometres beneath remote and stormy seas, for which extensive simulation studies are inevitable to avoid making incorrect, costly decisions.

____________________**C**____________________ two types of models are needed. First, one needs a mathematical model that describes how fluids flow in a porous medium. These models are typically given as a set of partial differential equations describing the mass-conservation of fluid phases, accompanied by a suitable set of constitutive relations. Second, one needs a geological model that describes the given porous rock formation (the reservoir). The geological model is realized as a grid populated with petrophysical properties that are used as input to the flow model, and together they make up the reservoir simulation model.

Unfortunately, obtaining an accurate prediction of reservoir flow scenarios is a difficult task. One of the reasons is that we can never get a complete and accurate characterization of the rock parameters that influence the flow pattern. And even if we did, ____________________**D**____________________ since this would require a tremendous amount of computer resources that exceed by far the capabilities of modern multiprocessor computers. On the other hand, we do not need, nor do we seek a simultaneous description of the flow scenario on all scales down to the pore scale. For reservoir management it is usually sufficient to describe the general trends in the reservoir flow pattern.

In the early days of the computer, reservoir simulation models were built from two-dimensional slices with 102–103 Cartesian grid cells representing the whole reservoir. In contrast, contemporary reservoir characterization methods can model the porous rock formations by the means of grid-blocks down to the meter scale. This gives three-dimensional models consisting of multi-million cells. Stratigraphic grid models, based on extrusion of 2D areal grids to form volumetric descriptions, ____________________**E**____________________ and are the current industry standard. However, more complex methods based on unstructured grids are gaining in popularity.

Despite an astonishing increase in computer power, and intensive research on computation techniques, commercial reservoir simulators can seldom run simulations directly on geological grid models. Instead, coarse grid models with grid-blocks that are typically ten to hundred times larger are built using some kind of upscaling of the geophysical parameters. How one should perform this upscaling is not trivial. In fact, upscaling has been, and probably still is, one of the most active research areas in the oil industry. This effort reflects that it is a general opinion that, with the ever increasing size and complexity of the geological reservoir models, ____________________**F**____________________.

TRANSLATION BANK

I. *Translate into Russian.*

1. Reservoir engineering is a branch of petroleum engineering which requires candidates to be well equipped with the various skills in oil reservoir drilling and production. A reservoir engineer primarily uses computer models to carry out reservoir simulation and surveillance. The engineer employs techniques which help in establishing the

drilling plan of an oil well, along with cost-effective schemes for the reservoir depletion. He/she also plans the drilling project and looks for various ways to reduce the environmental impacts. However, the prime responsibility of a reservoir engineer is to ensure that an oil reservoir is good enough for highest economic recovery. To ensure this, the individual works over reservoir modeling, well drilling, well testing, forecasting of production and testing of reservoir fluids to name a few.

2. Reserves is an abstract concept that describes the total volume of future oil production that could be expected to be recovered, assuming that certain physical and economic conditions exist and continue to prevail for however long is required to obtain the production. A comparison to an office building is illustrative: an office building retains the same physical size and character whether the rents for the building go up or down. Reserves, on the other hand, may increase or decrease with changes in oil and/or gas price.
3. Implementation of enhanced recovery projects is expensive, time-consuming and people-intensive. Significant costs are often involved in the assessment of reservoir quality, the amount of oil that is potentially recoverable, laboratory work associated with the EOR process, computer simulations to predict recovery, and the performance of the project. One of the first steps in deciding to consider EOR is to select reservoirs with sufficient recoverable oil and areal extent to make the venture profitable. With any of the processes, the nature of the reservoir will play a dominant role in the success or failure of the process. Many of the failures with EOR have resulted because of unknown or unexpected reservoir problems. Thus, a thorough geological study is usually warranted.
4. Absolute permeability is the ability of a reservoir rock to allow fluids to flow through its pores. It indicates the flow capacity of formation. It is simply referred to as permeability. Absolute permeability is used to analyze the formation rock. Through the combination of permeability data with pore pressure, porosity and other parameters it is possible to estimate the productivity of the formations. It is expressed in Darcy's and denoted by letter K.
5. Pressure maintenance is a secondary recovery process that is implemented early during the primary producing phase before reservoir energy has been depleted. Pressure maintenance projects, which can be accomplished by the injection of either gas or water, will almost always recover more oil reserves than are recoverable by primary producing methods. For example, the return of gas to the formation early in the primary producing history of a field will permit higher rates of oil production.
6. In oil and gas extraction, a Christmas tree, or 'tree' (not 'wellhead' as sometimes incorrectly mentioned), is an assembly of valves, spools and fittings used for oil wells, gas wells, water disposal wells, water injection wells, gas injection wells, condensate wells and other types of wells. It was named as Christmas tree due to its crude resemblance to this decorated tree. Christmas trees are used in both subsea and surface wells. Commonly, there are two types of tree – subsea tree, and surface tree. A Christmas tree is not the same equipment as wellhead. They are different separate pieces of equipment. The Christmas tree is installed on top of wellhead. A well head can be used without a Christmas tree during drilling operations. Wells being produced with the rod pumps (nodding donkeys, pump jacks, etc.) frequently do not utilize any tree due to no pressure-containment requirement. The primary

function of a tree is to control the flow, usually oil or gas, out of the well. It may also be used to control the injection of gas or water into a non-producing well in order to enhance production rates of oil from other wells. When the well and facilities are ready to produce and receive oil or gas, tree valves are opened and the formation fluids are allowed to go through a flow line.

7. The material balance method is more complex than the volumetric method, but has the advantage of providing an estimate of recovery over time under certain conditions. The method has several forms and requires both an extensive pressure-volume-temperature (PVT) analysis of reservoir fluids and an accurate pressure history of the reservoir. The latter obviously requires that some production (5% to 10% of ultimate recovery) occur before the method can be used.

II. *Render the following into English.*

1. После бурения скважины, продуктивной в промышленных масштабах, что доказывает наличие месторождения нефти, на первый план выдвигается проблема оценки размеров данного месторождения. Следует определить продуктивную площадь и выделить на ней наиболее нефтеносные участки.
2. После установления данной площади как продуктивной, нефтедобывающая компания начинает составлять программу разработки, которая сможет защитить ее собственность от отбора нефти компаниями, работающими на соседних участках, и обеспечить владельцу максимальную прибыль.
3. Обычно нефтедобывающая компания стремится к тому, чтобы вести разработку на максимальной площади минимальным числом скважин без риска расположить скважину за пределами области залегания нефти и получить таким образом сухую скважину, при этом продуктивность скважин должна рассматриваться в сочетании с затратами на бурение дополнительных скважин, чтобы определить их оптимальное число, которое обеспечит максимальную норму прибыли. Для решения этой задачи квалифицированный инженер-нефтяник применяет экономические принципы в сочетании с техническими талантами.
4. Инженер-разработчик суммирует геологические данные с данными по бурению для расчета наиболее благоприятного направления дальнейшей разработки от скважины, открывшей новое месторождение, на основании информации, полученной от этой скважины. Важными факторами при определении положения второй, третьей и последующих разведочных скважин, а также расстояний, которые могут отделять их от первой, является тип структуры, размер и протяженность ловушки или складки (*fold*).
5. Разработка нефтеносного участка обычно проводится согласно одному из нескольких планов. Типовым вариантом является бурение рядов скважин поперек участка от разведанного месторождения к неразведанной площади. Этот метод обеспечивает максимальное снижение риска пробурить сухую скважину в том случае, если нефтедобывающая компания не уверена, что участок целиком продуктивен, причем в этом случае появляется возможность сохранения жизненно важной информации о структуре приповерхностного слоя в районе новой буровой площади перед бурением новых скважин. Похожим

планом является последовательное бурение в направлении наружу от продуктивных опытных скважин. которые служат центрами.

6. При составлении схемы разработки участка имеют значение некоторые дополнительные факторы:
   - механизм вытеснения нефти (*oil displacement mechanism*) из коллектора;
   - регулирование дебита (темпа добычи) нефти;
   - необходимое количество наземного оборудования;
   - удобное расположение коммунальных сооружений (*utility facilities*) и коммуникаций;
   - возможность сбыта и рыночная стоимость;
   - государственное регулирование.
7. Под моделью в широком научном смысле этого слова понимают реально или мысленно созданную структуру, воспроизводящую или отражающую изучаемый объект. Название модель происходит от латинского слова modulus, что означает “мера, образец”. Моделирование принадлежит к числу основных методов познания природы и общества. Оно широко используется в технике и является важным этапом в осуществлении научно-технического прогресса.
8. Создание моделей нефтяных месторождений и осуществление на их основе расчетов разработки месторождений - одна из главных областей деятельности инженеров и исследователей-нефтяников. На основе геолого-физических сведений о свойствах нефтяного, газового или газоконденсатного месторождения, рассмотрения возможностей систем и технологий его разработки создают количественные представления о разработке месторождения в целом. Система взаимосвязанных количественных представлений о разработке месторождения - модель его разработки, которая состоит из модели пласта и модели процесса разработки месторождения.
9. Главная задача инженера, занимающегося расчетом разработки нефтяного месторождения, заключается в составлении расчетной модели на основе отдельных представлений, полученных в результате геолого-геофизического изучения месторождения, а также гидродинамических исследований скважин.
10. Современные компьютерно-вычислительные (*computer-aided*) достижения позволяют со значительной детальностью учитывать свойства пластов и происходящих в них процессов при расчетах разработки месторождений.

SPEAKING

I. *What are the following methods used for by reservoir engineers?*

- Formation evaluation
- Pressure transient analysis
- Material balance
- Volumetric analysis
- Well testing
- Reservoir simulation
- Production forecasting
- Economic modeling

- PVT analysis

II. *Work with a partner. Choose one of the methods mentioned in ex. I and describe how it works. You can make use of the tips given in the SPEAKING SECTION of Unit II.*

III. *There are some other methods related to reservoir engineering.* ***Decline curve analysis*** *is one of them. Find out what it involves and what it is used for using the link http://www.petropedia.com. or other sources.*

IV. *Discuss in the group.*

- *What oil recovery methods are most widely used in Russia? Why?*

V. *Choose any oil-producing country and give a talk/presenatation on its hydrocarbon reserves and the methods used for oil and gas recovery.*