# 2. ПРАКТИЧЕСКИЙ РАЗДЕЛ

# 2.1 Учебные материалы для практических занятий

## UNIT 1

## Oil and Gas Engineering in Belarus and Abroad

### Vocabulary

upstream – верхний сегмент (разведка и добыча)
downstream – нижний сегмент (переработка и сбыт)
midstream – средний сегмент (транспорт и хранение)
vertically integrated company – вертикально интегрированная компания
state-owned – государственный
oilfield services – нефтепромысловые услуги
refining – переработка нефти
geological exploration – геологическая разведка
production – добыча
energy security – энергетическая безопасность
domestic – внутренний (отечественный)
imported crude – импортная сырая нефть
land-based – наземный (сухопутный)
offshore – морской шельфовый
challenging reservoir conditions – сложные коллекторские условия
skill transfer – передача навыков
infrastructure – инфраструктура
workforce – рабочая сила
petroleum sector – нефтяной сектор
global demand – мировой спрос
transition – переход (энергетический)
capability beyond petroleum – компетенции за пределами нефтегаза

***Useful speech patterns:***

- *Belorusneft is a state-owned vertically integrated petroleum company established in 1966.*
- *Unlike Belarus, Norway used its petroleum sector as a platform for broader industrialization.*
- *In contrast to offshore projects, Belarusian operations are entirely land-based.*
- *The company performs geological exploration, oil and gas production, refining, and oilfield services.*
- *Beyond petroleum, oil and gas skills are transferrable to renewable energy and infrastructure.*

- *The sector employs approximately X people across upstream and downstream activities.*
- *While global oil demand has fallen below 30% of total energy, gas demand has hit a new all-time high.*
- *Compared to the Middle East, Belarusian fields are characterized by challenging reservoir conditions.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. Belarus has abandoned its domestic oil production entirely and now focuses only on importing crude oil from OPEC countries to meet global demand.
2. While Belarus is a state-owned vertically integrated company focused on refining imported crude, international majors are mainly concerned with offshore exploration under challenging reservoir conditions.
3. To ensure energy security, Belarus leverages its oilfield services and skill transfer capability beyond petroleum, adapting to global transition while international companies focus on offshore production under challenging reservoir conditions.

## Text A

The global petroleum sector is currently undergoing a profound **transition**, balancing the immediate need for **energy security** with long-term sustainability goals. In this landscape, the engineering strategies of major players vary significantly, from **land-based** operations in mature basins to high-risk **offshore** frontiers.

In Belarus, the industry is dominated by **Belorusneft**, a **state-owned vertically integrated petroleum company** that manages the full spectrum of operations. Its activities encompass **geological exploration** and **production** (**upstream**), **refining** at domestic plants like Mozyr (**downstream**), and the operation of pipeline networks (**midstream**). Because Belarus relies on **imported crude** to supplement its limited domestic output, the company's role is critical to national **energy security**. To maximize recovery from mature fields under **challenging reservoir conditions**, Belorusneft has heavily invested in **oilfield services** and **skill transfer**, creating a specialized **workforce** that is now its primary export commodity.

Looking **abroad**, the challenges are different. International majors are racing to close a projected supply gap through **offshore** ultra-deepwater exploration, which requires solving extreme engineering problems that are absent in Belarus's land-based Pripyat Trough. However, Belarus is leveraging its **capability beyond petroleum**. Facing sanctions, Minsk is exporting its engineering **infrastructure** expertise to new markets. For instance, Belorusneft is applying its drilling and **production** know-how in regions like Africa and Latin America, offering **oilfield services** and technical training as a form of diplomatic **skill transfer**. This strategy allows the nation to remain relevant in the **midstream** logistics market and adapt to fluctuating **global demand**, even as the domestic focus remains on sustaining mature assets.

**Exercise 2. Define whether the following statements correspond to the content of the text (yes, no).**

1. Belarus relies entirely on its own domestic crude production without any imports.
2. Belorusneft is a state-owned vertically integrated company.
3. The text mentions that offshore operations are free from challenging reservoir conditions.
4. Belarus is exporting its oilfield services and engineering expertise to other countries.
5. The global petroleum sector is not undergoing any transition according to the text.
6. Belorusneft is applying its production know-how in regions such as Africa and Latin America.
7. The text states that international majors prefer land-based operations over offshore exploration.
8. Energy security is a critical concern for Belarus due to its reliance on imported crude.
9. The text claims that Belarus has no capability beyond petroleum.
10. Midstream operations in Belarus include the management of pipeline networks.
11. Skill transfer and workforce development are unimportant for Belarus's petroleum sector.

**Exercise 3. Match the terms with their definitions.**

| | |
|---|---|
| 1. transition | **a.** to make a substance pure by taking other substances out of it. |
| 2. offshore | **b.** the segment of the energy industry that acts as the critical link between exploration/production and refining/marketing. |

| | |
|---|---|
| 3. refining | **c.** the total number of workers in a specific undertaking. |
| 4. upstream | **d.** movement, passage, or change from one position, state, stage, subject, concept, etc., to another; change. |
| 5. downstream | **e.** the global processes of exploration, extraction, refining, transportation, and marketing of crude oil and natural gas. |
| 6. midstream | **f.** the total quantity of goods, services, or commodities that consumers, businesses, and governments worldwide are willing and able to purchase at a given price level. |
| 7. oilfield services | **g.** at a distance from the shore, on a body of water. |
| 8. workforce | **h.** a receptacle or chamber for holding a liquid or fluid. |
| 9. skill transfer | **i.** of or for any of the stages prior to oil production, such as exploration or research. |
| 10. imported crude | **j**. the stage of extracting hydrocarbons (crude oil, natural gas, and associated liquids) from underground reservoirs to the surface, followed by processing, treating, and transporting these products. |
| 11. petroleum sector | **k.** of or for the refining, distribution, or marketing of oil or its derived products. |
| 12. global demand | **l.** the process of applying knowledge, abilities, and expertise acquired in one context to a new, different context or role |
| 13. reservoir | **m.** all of the products and services that help with oil and gas exploration and production. |
| 14. production | **n.** foreign-sourced petroleum (liquid hydrocarbons) brought into a country from abroad to meet domestic demand. |

**Exercise 4. Give your own interpretation of the following words and word combinations used in the text.**

land-based, energy security, state-owned, capability beyond petroleum, offshore, geological exploration, infrastructure.

**Exercise 5. Give a) synonyms and b) antonyms of the given words from Text A.**

**a)** changeover, seaward, international, competence, groundwork, personnel, oil rig;
**b)** onshore, local, within reach, stagnation, exported, destruction, unrestricted.

**Exercise 6. Read the text. Identify and analyse the key differences and similarities between the oil and gas engineering sectors in Belarus and those abroad.**

## Text B

Oil and gas stakeholders have been urged to deliberately transform skills developed in the petroleum sector into a foundation for broader national industrial growth and economic transformation.

As Uganda's oil and gas industry moves closer to the production phase, questions have continued to emerge over why the country is still investing heavily in skilling Ugandans in petroleum-related disciplines.

In 2014, international oil companies released the Industrial Baseline Survey report, which projected that the Lake Albert Basin Development project would create between 100,000 and 150,000 jobs through direct, indirect and induced employment. The companies called on government to ensure the availability of skilled labour, goods and services capable of meeting both international oil industry standards and sector demands. One survey at the time estimated that the sector would require 15 per cent engineers and managers, 60 per cent technicians and craftsmen, and 25 per cent unskilled workers. The report further recommended that government work closely with oil companies to ensure the education system produces qualified graduates certified to work in the oil fields in line with international practice.

Over the years, Uganda has trained petroleum engineers, geoscientists, civil engineers, electrical engineers and mechanical engineers, among others. Hands-on training has also been conducted in welding, scaffolding, heavy goods vehicle driving and Health, Safety and Environment (HSE).

So far, about 14 institutions have attained international certifications, while more than 4,000 Ugandans are estimated to have acquired practical skills related to the oil and gas industry. Under the Workforce Skills Development Strategy and Plan for Oil and Gas 2015–2025, the skilling component was estimated to cost £120 million.

While some trainees have secured employment within the industry, concerns have emerged over whether Uganda should continue investing in certain specialised skills, particularly after some highly skilled welders reportedly failed to secure opportunities within ongoing oil and gas operations.

According to Ifelebuegu, oil and gas skills are transferable and can support multiple sectors of the economy beyond petroleum production. "A welding technician trained in pipeline construction has expertise in precision fabrication, quality inspection, safety compliance and international standards," he said. "That person can work in manufacturing, automotive assembly, railway systems, construction, mining and renewable energy infrastructure."

He explained that the oil and gas industry is built around discipline, precision, safety and systems thinking, qualities essential across modern industries. "The oil and gas industry operates under extreme technical, financial, environmental and safety demands," he said. "A mistake in banking may result in financial loss, but a mistake in oil and gas can cost lives, destroy ecosystems, damage economies and harm national reputation."

Because of the high-risk nature of the industry, he argued, the sector naturally produces professionals well suited for leadership roles in other sectors. "Workers in this sector, regardless of what they do, are trained in risk management, quality assurance, environmental protection, emergency response, logistics coordination and project execution," he said. "These are not just petroleum skills. These are advanced industrial competencies."

Ifelebuegu urged Uganda to learn from countries such as Norway, South Korea, Germany and Malaysia, which used their resource sectors as a platform for broader industrialisation. "In Norway, oil was not treated as an end in itself," he explained. "It was used as a foundation for building national engineering capacity, research institutions and supplier industries."

He noted that Norway's petroleum expertise later supported offshore wind, marine engineering, robotics and carbon capture technologies.

He also cited South Korea's industrial growth, where early investments in shipbuilding, petrochemicals and heavy engineering eventually supported the rise of global automotive giants such as Hyundai.

He pointed to Nigeria as an example of both progress and missed opportunities in linking petroleum expertise to broader economic diversification.

The professor further highlighted projects such as the East African Crude Oil Pipeline (EACOP) as important training grounds for national industrial skills development. "These projects involve cross-border coordination, engineering integration, logistics systems, environmental monitoring and community engagement," he said. "The skills developed here must not end here."

According to Ifelebuegu, such competencies can later support the development of smart cities, renewable energy systems, industrial parks, water infrastructure and transport networks. He added that environmental specialists trained within the oil and gas sector are equally valuable across agriculture, tourism, urban development and climate adaptation programmes.

**Notes:**

***stakeholders*** заинтересованные стороны, участники отрасли
***hands-on training*** практическое обучение (без отрыва от производства)
***welding*** сварка
***scaffolding*** монтаж лесов / лесостроение (строительных лесов)

***Health, Safety and Environment (HSE)*** охрана труда, техника безопасности и окружающая среда
***Workforce Skills Development Strategy*** стратегия развития квалификации рабочей силы
***an end in itself*** самоцель

**Exercise 7. Answer the following questions to the text.**

1. What type of company is Belorusneft in terms of ownership and vertical integration?
2. Which activities in Belarus belong to upstream, midstream, and downstream sectors?
3. Why is energy security a critical concern for Belarus?
4. What kind of oilfield services does Belarus export to regions like Africa and Latin America?
5. What percentage of engineers and managers was estimated to be required in Uganda's oil sector?
6. Why did some highly skilled welders reportedly fail to secure opportunities in Uganda's oil and gas operations?
7. According to Ifelebuegu, in which sectors can a welding technician trained in pipeline construction work besides oil and gas?
8. Which countries does Ifelebuegu cite as examples of using resource sectors as a platform for broader industrialization?
9. How does state ownership in Belarus influence skill transfer compared to Uganda's reliance on international oil companies?
10. Which country appears more focused on energy security versus job creation?

**Exercise 8. Make up the plan of the text and render its content.**

# UNIT 2

## Robotics in Oil and Gas: Extraction, Inspection, and Maintenance

### Vocabulary

autonomous – автономный
robotic crawler – роботизированное гусеничное устройство
nondestructive testing – неразрушающий контроль
inspection – инспекция / обследование
maintenance – техническое обслуживание

drone – беспилотный летательный аппарат (дрон)
laser descaling – лазерное удаление окалины / отложений
harsh environment – агрессивная среда
corrosion – коррозия
real-time data – данные в реальном времени
onboard electronics – бортовые электронные системы
sensor – датчик / сенсор
remote operation – дистанционное управление
robotic pig – роботизированный скребок
tank inspection – обследование резервуара
hydrogen-induced cracking – водородное растрескивание
autonomous drilling – автономное бурение
tool face orientation – ориентирование отклонителя
without hydraulic supply lines – без гидравлических линий подачи
payload – полезная нагрузка
dexterous manipulation – манипулирование с высокой точностью
confined space – замкнутое пространство

***Useful speech patterns:***

- *The industrial robot is designed to withstand corrosion in hostile environments.*
- *Kantori™ autonomous well construction solution combines AI with real-time data analytics.*
- *Robotic crawlers are used for nondestructive testing and tank inspections.*
- *The equipment is capable of moving within pipelines without requiring a pressure difference.*
- *Drones and laser descaling robots reduce costs, time, and safety risks.*
- *The technology aims to eliminate the need for hydraulic supply lines.*
- *Sensors and onboard electronics capture real-time measurements at the rock-bit interface.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. The oil and gas industry is being transformed by autonomous and remotely operated robots that perform drilling, nondestructive testing, tank inspection, laser descaling, and maintenance in harsh environments, confined spaces, and other dangerous locations where human access is limited.

2. The most important application of robotics in the oil and gas industry is the use of drones for tank inspection, because drones can carry gas sensors and provide real-time data without exposing personnel to risk.
3. Laser descaling is the primary innovation in oil and gas robotics, as it allows operators to remove hard mineral scale and corrosion using a high-energy laser combined with a water jet, which preserves pipe integrity better than traditional methods.

## Text A

(1)The digitization of the oil and gas industry has moved beyond simple mechanization, evolving into an era of true **autonomous** systems that redefine extraction, inspection, and maintenance. This transition is not merely about automation; it is about creating closed-loop systems capable of interpreting downhole conditions and executing complex workflows without human intervention.

(2)In the drilling sector, the shift toward **autonomous drilling** is overcoming the limitations of traditional automated tasks. Historically, directional drillers had to constantly adjust the **tool face orientation** to maintain trajectory. Today, advanced systems utilize **real-time data** from downhole **sensors** to coordinate every aspect of well construction. These intelligent systems manage **tool face orientation** and steering settings autonomously, optimizing the well path while accounting for geological changes. This capability is critical for operating **without hydraulic supply lines**, simplifying bottom hole assemblies (BHA) and reducing mechanical complexity in extreme downhole environments.

(3)Once extraction is underway, maintaining the integrity of infrastructure often requires operation in **harsh environments** where human access is dangerous or impossible. Many critical assets are located in **confined spaces** – such as narrow pipe galleries, subsea mud mats, and internal vessel chambers – where even a slim worker cannot safely enter. Here, **robotic crawlers** and **drones** have become indispensable. Modern inspection drones are designed with a high **payload** capacity, allowing them to carry multiple NDT **sensors**, gas detectors, and even robotic arms for light intervention. For internal pipeline inspections, the industry relies on the **robotic pig**. Unlike standard cleaning pigs, these intelligent devices are packed with **onboard electronics** and sensors to detect anomalies while traversing the pipeline.

(4)For storage and processing facilities, **tank inspection** has been revolutionized by aerial and ground robotics. Companies like MODEC and Terra Drone have partnered to deploy **drones** equipped with ultrasonic

**sensors** and gas detectors to perform **tank inspection** in volatile atmospheres. These drones are often tethered for continuous power, allowing for **remote operation** and the collection of **real-time data** without exposing personnel to risk. Similarly, **nondestructive testing** (NDT) has been automated using Phased Array Ultrasonic Testing (PAUT) scanners mounted on robotic arms. This automation is particularly effective for identifying **hydrogen-induced cracking** (HIC) – a common fatigue failure in sour service – with a level of repeatability and accuracy impossible to achieve manually.

(5)Maintenance and remediation also benefit from robotic intervention. Surface **corrosion** and hard mineral scale can cripple flow efficiency. To address this, the industry is adopting **laser descaling** techniques. By utilizing a high-energy laser to thermally weaken hard carbonate scales, a subsequent water jet can remove debris with lower pressure than traditional methods, preserving the integrity of the pipe while effectively removing blockages. In cases where physical repair is needed inside a reactor or a **confined space**, modern robotic systems now offer **dexterous manipulation**. These are multi-axis articulated arms, often mounted on a **robotic crawler**, that can perform tasks such as tightening bolts, applying sealants, or removing **corrosion** products in areas where a human hand cannot reach. This **dexterous manipulation** is critical for performing **maintenance** without draining or degassing an entire vessel.

(6)The future of upstream operations lies in full integration. Centralized control rooms now dispatch ground robots and flying **drones** not just to observe, but to act. These systems conduct **inspection**, perform **laser descaling**, and compile data into digital twins. When a **robotic crawler** detects a defect, the system can autonomously launch a mission to verify the repair. This holistic approach – integrating everything from **autonomous drilling** to **remote operation** of repair robots – is reducing downtime by up to 30% and marking a true step-change in asset management.

**Exercise 2. Give the number of the paragraph which expresses the following ideas.**

1. The oil and gas industry is moving toward autonomous systems that can perform drilling, inspection, and maintenance without human intervention.
2. Autonomous drilling systems use real-time data from downhole sensors to manage tool face orientation and steering without hydraulic supply lines.
3. Robotic crawlers and drones are deployed in confined spaces such as narrow pipe galleries and subsea mud mats where human access is dangerous or impossible.

4. Drones designed for industrial use carry a high payload, allowing them to transport multiple tools.
5. The robotic pig is an intelligent pipeline inspection tool equipped with onboard electronics and sensors that detect anomalies in the pipeline.
6. Tank inspection in volatile atmospheres is now performed by tethered drones that enable remote operation and deliver real-time data.
7. Laser descaling uses a high-energy laser to weaken hard carbonate scales.
8. Modern robots equipped with dexterous manipulation can perform maintenance tasks such as tightening bolts or removing corrosion products inside a reactor or other confined space.

**Exercise 3. Define whether the following statements correspond to the content of the text (yes; no; not stated).**

1. Autonomous drilling systems can adjust tool face orientation without human help using real-time data from downhole sensors.
2. Traditional drilling systems already operate completely without hydraulic supply lines in most offshore fields.
3. Robotic crawlers and drones are used in confined spaces such as narrow pipe galleries and subsea mud mats.
4. All industrial drones used for tank inspection are powered by batteries and do not require a tether.
5. Phased Array Ultrasonic Testing (PAUT) mounted on robotic arms can detect hydrogen-induced cracking in sour service environments.
6. Laser descaling completely replaces all traditional mechanical cleaning methods in the oil and gas industry.
7. Robots equipped with dexterous manipulation can perform maintenance tasks such as tightening bolts or applying sealants in confined spaces.
8. The use of robotics in oil and gas has increased downtime by approximately 15% due to system complexity.
9. The robotic pig is equipped with onboard electronics and sensors to detect anomalies inside pipelines.
10. Drones used for tank inspection in volatile atmospheres allow remote operation and send real-time data to operators.
11. Hydrogen-induced cracking can only be detected by visual inspection performed by human divers.

**Exercise 4. Match the terms with their definitions.**

| | |
|---|---|
| 1. autonomous | **a.** a semi-autonomous or remote-controlled device designed for traversing surfaces using tracks or wheels |
| 2. drilling | **b.** a setting where survival or normal operation is extremely difficult, often impossible, due to severe, extreme conditions |
| 3. dexterous manipulation | **c.** an intelligent, autonomous, or tethered device used to inspect, clean, and maintain the internal integrity of industrial pipelines |
| 4. robotic crawler | **d.** able to operate with little or no human control or intervention |
| 5. harsh environments | **e.** the natural, gradual deterioration of materials – primarily metals – through chemical or electrochemical reactions with their environment |
| 6. robotic pig | **f.** the use of advanced, multi-fingered robotic hands or specialized end-effectors capable of performing complex, precise, and human-like manipulation tasks, particularly in hazardous or hard-to-reach environments |
| 7. payload | **g.** the process of creating a borehole in the Earth's surface using specialized rigs to access, explore, and extract hydrocarbon resources like oil and natural gas trapped in underground geological formations |
| 8. drone | **h.** an advanced, non-contact cleaning process that uses high-energy laser pulses to remove oxides, rust, paint, and other contaminants from metal surfaces |
| 9. tank inspection | **i.** an enclosed or partially enclosed area that is not designed for continuous human occupancy, has limited means of entry/exit, and poses risks of injury or death |
| 10. onboard electronics | **j.** information that is delivered, processed, and made available for analysis immediately after it is generated or collected |
| 11. corrosion | **k.** a form of material degradation where atomic hydrogen diffuses into steel, accumulating at internal defects to create high-pressure molecular hydrogen, leading to internal cracks, blisters, or reduced ductility |

| | |
|---|---|
| 12. laser descaling | **l.** the total weight of the cargo, materials, tools, or equipment that a vehicle is carrying, excluding the weight of the vehicle itself |
| 13. maintenance | **m.** the computational estimation of where a human's face (or a robotic face) is pointing in 3D space |
| 14. confined space | **n.** a systematic, mandated evaluation of storage tanks using visual and non-destructive testing (NDT) to ensure structural integrity, prevent leaks, and comply with safety regulations like API 653 |
| 15. real-time data | **o.** a device, module, or subsystem that detects changes in its environment and converts them into signals |
| 16. sensor | **p.** an Unmanned Aerial Vehicle (UAV) or specialized Unmanned Aerial System (UAS) utilized for remote, automated, or pilot-operated aerial inspections and monitoring of infrastructure |
| 17. nondestructive testing | **q.** the process of preserving, repairing, or keeping equipment, machinery, buildings, or systems in good working condition, ensuring they operate efficiently and do not fail |
| 18. hydrogen-induced cracking | **r.** the integrated electronic systems, components, and computing hardware installed directly onto a vehicle, vessel, aircraft, spacecraft, or machine to manage, monitor, and control its operations |
| 19. face orientation | **s.** a set of analysis techniques used in industry to evaluate the properties, integrity, or condition of materials, components, or systems without damaging or altering them |

**Exercise 5. Give your own interpretation of the following words and word combinations used in the text.**

drilling section, aerial and ground robotics, manually, subsea mud mats, flow efficiency, indispensable, downhole environments.

**Exercise 6**. **Answer the following questions to the text.**

1. How do autonomous drilling systems manage tool face orientation without human intervention?
2. Why is it important for autonomous drilling systems to operate without hydraulic supply lines?
3. What allows modern inspection drones to carry multiple NDT sensors and gas detectors at the same time?
4. What is a robotic pig, and what is its function in pipeline inspection?
5. What onboard features enable the robotic pig to detect anomalies inside a pipeline?
6. How do tethered drones improve the safety of tank inspection in volatile atmospheres?
7. What nondestructive testing method is mentioned as being automated using robotic arms?
8. What type of material defect can automated Phased Array Ultrasonic Testing (PAUT) detect in sour service environments?
9. How does laser descaling remove hard mineral scale without damaging the pipe?
10. According to the text, what percentage of downtime reduction can be achieved by integrating autonomous inspection and repair systems?
11. Why is remote operation particularly valuable for maintenance work in harsh environments?

**Exercise 7. Read the text. Find in the text and put down key words that can be used to speak about the topic.**

## Text B

The increasing versatility of unmanned, robot submersibles is coming to the aid of an offshore oil and gas industry moving into depths beyond the limitations of human divers. No longer just a "swimming camera" capable of observation alone, the remotely controlled undersea vehicle tethered to a mother ship today can carry tools for cutting, cleaning, and a multiplicity of other tasks required for such deepwater jobs as inspection and repair. The technology is still evolving, as drones linked to the surface by radio waves alone conduct topographic surveys or search for minerals on a seabed often hundreds of meters below.

With a remotely operated vehicle (ROV) there is virtually no limit on working time, no expense for breathing gas, and none of the time and money involved in decompression of divers at the end of an assignment. This is an important factor when production wells operate in water depths of approximately three hundred and five meters – the working limit for most commercial divers – pipelines are installed at six hundred meters below the ocean surface, and exploratory drilling reaches to depths of fifteen hundred meters and beyond.

Currently, use of an unmanned underwater craft falls into one of three categories – surveillance, light work, or heavy work – but each manufacturer or user defines them in their own way. And the definitions are often applied loosely.

The remotely operating vehicle is a self-contained unit capable of operating continuously – as long as surface weather permits. Electrical power, video signals, and electronic commands from the operating hut on board the mother ship are sent through an umbilical cord strong enough to lift the craft out of the water. Through this connection, one or two operators can manipulate the undersea unit and its two multi-tooled hydraulic arms as extensions of themselves – monitoring and controlling repair work as easy as if they were on the ocean floor. Manipulator- or robot- arms can be used, for example, to open or shut pipeline valves, and operate valves that help control the flooding of platform jackets when they are lowered to the seabed. The arms can locate and "feel" gaps during inspection or building, and retrieve drilling equipment, such as acoustic beacons used to position exploration and production units.

On the operating consoles of most tethered unmanned submersibles, the direction and speed provided by small thruster motors are controlled by a three-way "joystick", a term borrowed from the aviation industry because the ROV manoeuvring system is more like that of a helicopter than a boat. The remote unit generally does not have rudders or other movable control surfaces because a speed that rarely exceeds four knots makes such steering arrangements cumbersome. Instead, thruster motors provide movement in all directions – forward-back, up-down, side-to-side – so the operator can maintain tight control of the vehicle in the waters beneath him.

**Exercise 8. Make up the summary of the text.**

## UNIT 3

## Drilling and Well Construction

### Vocabulary

drilling rig – буровая установка
rotate – вращать
drill pipe – бурильная труба

pull out – извлекать (поднимать)
run pipe back – спускать трубы обратно
lower – опускать
circulate – циркулировать
drilling fluid – буровой раствор
support – поддерживать
control – контролировать, регулировать
drill out – разбуривать
test – испытывать, проверять
pressure up – создавать давление, опрессовывать
check for leaks – проверять на утечки
raise – поднимать, увеличивать
bleed off – стравливать (давление)
hold (pressure) – держать (давление)
squeeze (job) – цементирование под давлением (скважины)
displace – вытеснять, продавливать
spot (cement) – устанавливать (цемент) в заданном месте
tag (cement) – доходить до (цементной) пробки, фиксировать глубину
set (tool) – устанавливать (инструмент)
trip out / in – поднимать / спускать инструмент

***Useful speech patterns:***

- *The expandable casing technology isolates problematic zones while maintaining the original internal diameter.*
- *Equivalent circulating density (ECD) should not exceed formation fracture gradient.*
- *Hydraulic fracturing was performed to bypass near-wellbore damage.*
- *ESP was selected due to high fluid volumes and increasing water cut.*
- *Well control procedures shall comply with industry standards.*
- *The well was shut in for a pressure build-up test.*
- *Sand production was controlled by installing a gravel pack.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. The most important function of a drilling rig is to pull the drill pipe out of the hole for bit changes, and all other operations like circulating mud or testing pressure are optional and rarely performed.
2. Proper well control requires calculating hydrostatic pressure, testing the casing shoe to a predetermined EMW (equivalent mud weight), and if the

shoe fails, performing a squeeze job using precise displacement calculations to avoid cementing tools or causing formation damage.
3. The cable tool rig is the most modern and efficient method for drilling deep high-pressure wells, and it has completely replaced the rotary rig in all offshore operations.

## Text A

A drilling rig is a large and complex mechanism whose basic function is relatively simple. Its function is to rotate a string of drill pipe and drill a hole in the ground. It must also pull the drill pipe out of the hole for drill bit changes and run pipe back into the hole. The rig is really a giant crane for lifting and lowering drill pipe, with a rotary table to rotate the pipe. That is why it is called a rotary rig. A more ancient method known as the cable tool rig is not used on deep or high pressure wells and will rarely be used any more, except to hold a lease until a rotary rig becomes available.

The drilling rig must be able to perform certain secondary functions such as circulating drilling fluid to clean the well-bore and support the weight of the drill string so that the weight on the bit can be controlled. For example, if the string weighs 200,000 lb and only 30,000 lb of weight is needed on the bit, the rig must support 170,000 lb of the string while the well is being drilled.

Before the drilling operation can get underway again, the surface casing must be drilled out and tested 10 ft below the shoe (Gulf Coast area). To do this, strap and record the depth that the cement is tagged. Then close the annular preventer and pressure up on the casing with the rig pump through the drill string. Pressure up to 1,500 psi or whatever the prognosis calls for. Check the casing for leaks. If there are no leaks, proceed with the next step. If the casing leaks, call for a squeeze tool and find the leak, because a cement job will be necessary. In this section we assume the test passed with no leaks.

Next drill out the float collar and cement 10 ft above the guide shoe. Test the casing to 1,500 psi again to check for leaks in the float collar threads. Drill out the shoe and 5 ft of the new formation. Check the prognosis to determine what equivalent mud weight (EMW) to pressure up on the shoe. The EMW is the predetermined test pressure based on the geology to which the operator wants to test the casing shoe. The test is given if the well is going to encounter high-pressure gas. On the Gulf Coast normally a 13.5 ppg (pounds per gallon) mud weight is used to test the surface shoe. The EMW is what is needed at the shoe depth, before drilling begins. The operator will put on the prognosis the shoe test pressure. If the shoe is tested and holds, then if the mud weight needs to be raised to the weight of 13.5 ppg, the shoe will hold and not leak. To find the EMW, first find the existing mud weight in the tanks. Then do the following calculation (0.052 is the constant for converting ppg to psi): depth × mud weight (ppg) × 0.052 = BHP (Bottomhole Pressure) (example: 3,014 ft (depth) × 8.9 ppg (mud weight) × 0.052 = 1,394 psi).

Next find the hydrostatic pressure on the EMW, as listed in the prognosis and do the following calculation: depth × EMW × 0.52 = psi (example: 3,014 ft (depth) × 13.5 ppg (EMW) × 0.52 = 2,115 psi). Now subtract existing pressure from the test pressure of EMW: 2,115 – 1,394 = 721 psi.

So 721 psi will be needed at the surface to get the EMW of 13.5 ppg mud. Pressure up on the shoe by closing the annular preventer, using the rig or a cement truck pump. Hold the 721 psi for five or ten minutes. If it holds, bleed the pressure off and begin drilling. (Note: When pressuring up, do it only 100 psi at a time until 721 psi is reached.)

If the shoe does not hold the pressure, and it bleeds off, determine what pressure the shoe will hold to see if a squeeze job is needed. For example, if the pressure bleeds back to 300 psi, calculate the EMW to see what the shoe will hold. Take the existing 1,394 psi and add the 300 psi to it: 1,394 + 300 = 1,695 psi. Then divide back to find the EMW: 1,694 psi ÷ 0.52 ÷ 3,014 ft (depth) = 10.8 ppg (EMW).

Since the shoe will only hold a 10.8 ppg mud weight, a squeeze job will have to be run. Inform the operator of this development, and if your advice is requested, tell the operator to run a squeeze job to be safe. It would be a mistake to drill with a weak shoe. If you do not get the shoe to test and you hit high-pressure gas, the shoe can fail. Sometimes the breakdown will channel to the surface and crater the rig. Testing the shoe is serious business. When the shoe is being tested you should be on location and watch the gauge personally. This will keep the hands from cheating on the test. In hard rock areas the shoe does not have to be tested because of the greater fracture pressure needed to break down the formation.

Call a service company that has a squeeze tool, and they will furnish a tool hand to run the tool. Then order out the cement and a truck to pump it. Normally on a surface squeeze 150 to 200 sacks of cement are needed. Some consultants prefer 200 sacks on the first squeeze, depending on how fast the formation takes the pressure. A decrease in pressure means mud is being pumped into the formation. The faster the pressure loss the more cement will be needed. Order out two loads of cement, so if the first 200 sacks do not squeeze off the formation, a second load will be ready to mix and pump.

Pull out of the hole while you are waiting for the squeeze tool hand and the cement. Decide where you need to place the squeeze tool so you can tell the tool hand where to set it. If, for example, you want it to set 15 bbl from the shoe, perform the following calculations to convert barrels into feet. First look in the cement book for the barrels per foot for a 10 3/4 OD 40.50 lb/ft casing. There are 10.19 ft/bbl. Multiply that figure by 15 (the number of barrels needed): 10.19 ft/bbl × 15 bbl = 152.85 ft. This means that you want the tool to set 152.85 ft (153 ft rounded off) from the shoe. Subtract this figure from the shoe depth of 3,004 ft (i.e. 3,004 – 153 = 2,851 ft).

Next figure the capacity of the drill pipe. Say you are using 4.5-in. 16.60-lb/ft drill pipe. The capacity chart in the cement book shows that this pipe will hold 0.01422 bbl/ft. Calculate: 2,851 ft × 0.01422 bbl/ft = 40.54 bbl (rounded off 40.5 bbl to displace the squeeze tool).

You must leave 5 bbl in the casing under the squeeze tool. To do this determine the displacement under the tool by multiplying the 10.19 ft/bbl by 10. This yields 101.90 ft (rounded off to 102 ft). From the vendor cement books, you will find that the casing capacity is 0.0981 bbl/ft: 102 ft × 0.0981 = 10.01 bbl (10 bbl rounded off). So the total amount of displacement fluid needed is: 40.5 bbl + 10 bbl = 50.5 bbl Next convert the sacks of cement to barrels by first finding the cubic feet: $ft^3$ sacks yield (slurry yield) $ft^3 = 200 \times 1.20 = 240$ Then find the barrels: bbl $ft^3$ x 0.1781 (constant) bbl 240 x 0.1781 = 42.74 (43 rounded off)

Most consultants will spot the cement (that is, pump the cement to a designated place) by leaving the squeeze tool unset instead of bullheading the mud into the formation. Since we need to pump 43 barrels of cement, first pump 33 barrels, set the squeeze tool, and then pump the other 10 barrels. This will force the mud into the formation without causing any problems.

The cement was spotted because you don't ever want to pump cement around the tool. In this case, the pumping was stopped 10 barrels above the tool, and the squeeze tool closed, making it impossible for cement to be around the tool. This eliminated the possibility of getting the tool stuck or cemented in the hole – a very bad situation indeed.

Now pump the 50.5 bbl of displacement fluid to displace the cement into the formation and clear the tool to 51 ft above the guide shoe. Always add one barrel of displacement fluid to the calculation for fluid in the lines. So 51.5 bbl would be more accurate.

If the cement pumps without any pressure build-up, there probably is not a squeeze. If, while pumping, there is a pressure build-up, raise the pressure from 2,500 psi to 3,000 psi and check for backflow. If there is no backflow, the shoe is squeezed. If it backflows, repump the cement back down the hole and check for pressure build-up. Hold for five minutes and then release the pump and check again for backflow. If there is still backflow, the shoe is not getting a squeeze; so try again. Sometimes after three or four tries the pressure will squeeze off. If it does not, close the cement manifold on the floor and hold that pressure for eight hours, then release it.

During the last 10 barrels of the pumping operation of the squeeze, slow the pumping rate down to 0.5 bbl/min. Then on the last four barrels slow to 0.25 bbl/min. This will let the cement slowly squeeze into place and will not let a sudden build-up of pressure catch the cement operator off guard.

There is some controversy about the proper method for squeeze jobs. Some people prefer to release the squeeze tool and pull five stands of pipe to keep from cementing the tool in the casing. This is the poorest way to handle the job, because the purpose of the squeeze tool is to put the cement in place and enable the consultant to hold pressure against the squeeze to improve cement hardening and keep it from coming up the hole. If a squeeze tool gets cemented in the casing, the tool operator and the consultant have not correctly calculated the displacement.

If you do get a squeeze, release the tool and trip out of the hole, lay down the tool, make up the bit, and go back to bottom, short two stands. Next let the cement set for 18 hours, tag the cement, and record the depth of the tag. Then check the calculations for any errors.

As mentioned earlier, if there was not a pressure build-up when the displacement fluid was pumped, the squeeze was not successful. But that does not necessarily mean the formation will not hold. This is especially true in the Gulf Coast area. The gumbo and the soft formations will take the cement easier than anywhere in the world. It is like trying to cement sloppy mud. One of two things can be done:

1. Pump more cement down the hole in an effort to fill any hole or formation breakdown encountered.

2. Come out of the hole and let the cement set for 18 hours. Trip in and tag the cement. Then drill it out 6 ft below the guide shoe and retest it for 13.5 EMW.

As you drill, give the cuttings time to come to the surface and check for green (not yet dry) cement. Drill 5 ft of cement, and circulate out the cuttings. If the cement is hard, it is okay. If it crumbles, shut down the pumps and let it sit six to eight hours more. Never drill out green cement. The vibration of the rotating string will cause the cement to channel and ruin the squeeze.

When cement squeezes, it actually squeezes the water into the permeable formation, leaving cement (solid particles) on the walls and making them stronger. Some Gulf Coast jobs require three or four formation squeezes before the show will test, so do not get disappointed if the first time does not work. Once you get a good squeeze, drilling operations can begin. Lay the squeeze tool down, set up your bottom hole assembly, and start drilling.

**Exercise 2. Change the order of the following items according to the content of the text.**

1. Next figure the capacity of the drill pipe. Say you are using 4.5-in. 16.60-lb/ft drill pipe.
2. If the shoe does not hold the pressure, and it bleeds off, determine what pressure the shoe will hold to see if a squeeze job is needed.
3. Its function is to rotate a string of drill pipe and drill a hole in the ground.
4. Then close the annular preventer and pressure up on the casing with the rig pump through the drill string.
5. When the shoe is being tested you should be on location and watch the gauge personally.
6. The rig is really a giant crane for lifting and lowering drill pipe, with a rotary table to rotate the pipe.
7. Most consultants will spot the cement (that is, pump the cement to a designated place) by leaving the squeeze tool unset instead of bullheading the mud into the formation.
8. Before the drilling operation can get underway again, the surface casing must be drilled out and tested 10 ft below the shoe.
9. If you do get a squeeze, release the tool and trip out of the hole, lay down the tool, make up the bit, and go back to bottom, short two stands.
10. Pressure up to 1,500 psi or whatever the prognosis calls for.

**Exercise 3. Define whether the following statements correspond to the content of the text (true − T; false − F; not stated − NS).**

1. The basic function of a drilling rig is to rotate a string of drill pipe and drill a hole in the ground.
2. The cable tool rig is still widely used for drilling deep high-pressure wells.
3. A drilling rig can support part of the drill string weight so that the weight on the bit can be controlled.
4. The surface casing must be tested 50 ft below the shoe in all drilling operations.
5. The annular preventer is used to pressure up the casing during the shoe test.
6. The constant for converting ppg to psi is 0.052 according to the text.
7. On the Gulf Coast, a 15.0 ppg mud weight is normally used to test the surface shoe.
8. If the shoe fails the test, the operator should continue drilling and ignore the problem.

9. The author recommends testing the shoe without personally watching the gauge.
10. In hard rock areas, the casing shoe does not have to be tested because the formation has greater fracture pressure.
11. The author describes how to convert barrels into feet using a cement book.
12. A squeeze job always succeeds on the first attempt in the Gulf Coast area.

**Exercise 4. Match the terms in the left column with their definitions.**

| | |
|---|---|
| 1. drilling rig | **a.** a string of pipe that is rotated by the drilling rig to drill a hole; its weight is partially supported by the rig to control the weight on the bit. |
| 2. drill pipe | **b.** to release pressure slowly (e.g., if the shoe does not hold pressure and it bleeds off, meaning pressure decreases; also "bleed the pressure off" after a successful test). |
| 3. drilling fluid | **c.** to increase pressure in the casing by closing the annular preventer and using the rig pump or a cement truck pump (e.g., pressure up to 1,500 psi or to a calculated value like 721 psi to test the shoe). |
| 4. drill out | **d.** a large and complex mechanism whose basic function is to rotate a string of drill pipe and drill a hole in the ground; also a giant crane for lifting and lowering drill pipe with a rotary table to rotate the pipe. |
| 5. pressure up | **e.** fluid circulated by the rig to clean the wellbore (well-bore) and support the weight of the drill string. |
| 6. bleed off | **f.** to push cement or fluid into a desired position by pumping displacement fluid (e.g., displace the squeeze tool, displace the cement into the formation). |
| 7. displace | **g.** to drill through the surface casing, float collar, cement, and shoe (e.g., drill out the float collar and cement, drill out the shoe and new formation). |

**Exercise 5. Say what terms are meant by the following descriptions.**

a) EMW; b) ppg; c) psi; d) BHP; e) ECD.

1. A unit of pressure. It is used to measure casing test pressure, bottomhole pressure calculations, surface pressure required to achieve a target EMW, pump pressure during squeeze jobs.
2. A unit of density used to measure the weight of drilling mud. It is used to specify mud weight. It is a key value in calculating hydrostatic pressure using the constant 0.052.
3. It is the hydrostatic pressure exerted by the mud column at the bottom of the hole.
4. It is the effective density of the drilling fluid when it is circulating, accounting for frictional pressure losses in the annulus. It is typically higher than static mud weight and is expressed in ppg equivalent. It becomes important when circulating drilling fluid to clean the wellbore and when managing downhole pressure to prevent formation breakdown or kicks. In squeeze jobs and shoe tests, maintaining it below the fracture gradient is critical.
5. It is the predetermined test pressure based on the geology to which the operator wants to test the casing shoe. It is expressed in pounds per gallon and represents the mud weight needed at the shoe depth to simulate downhole pressure conditions. It is calculated to determine how much surface pressure is required to achieve the desired bottomhole pressure.

**Exercise 6. Answer the following questions to the text.**

1. What is the basic function of a drilling rig according to the first paragraph?
2. Why is a rotary rig called "rotary"?
3. What are the two secondary functions of a drilling rig mentioned in the second paragraph?
4. Why is the cable tool rig rarely used anymore?
5. What must be done before the drilling operation can get underway again (Gulf Coast area)?
6. What pressure does the text recommend pressuring up to when testing the casing (before proceeding)?
7. What is the constant used to convert ppg to psi, and what does it represent?
8. How is bottomhole pressure (BHP) calculated? Provide the formula from the text.
9. If the existing mud weight is 8.9 ppg at a depth of 3,014 ft, and the target EMW is 13.5 ppg, how much surface pressure is needed? (Show the calculation as described in the text.)

10. What should you do if the casing shoe does not hold the pressure and bleeds off?
11. Why is it a mistake to drill with a weak shoe? What are the possible consequences mentioned in the text?
12. How many sacks of cement are normally needed for a surface squeeze on the Gulf Coast, and what do some consultants prefer?
13. How do you convert barrels into feet to determine where to set the squeeze tool? Use the example from the text (15 bbl, 10.19 ft/bbl).
14. Why do most consultants spot the cement by leaving the squeeze tool unset instead of bullheading?
15. What should you do if the cement is still green (crumbles) after drilling 5 ft of it? Why is it dangerous to drill out green cement?

**Exercise 7. Read the text. Find in the text and put down key words that can be used to speak about the topic.**

## Text B

This is a simple procedure that allows the operator to evaluate the geology of the well more accurately. It requires obtaining a 3.5-in. diameter core from the well and analyzing it in a laboratory.

The conventional coring method is used more than wire-line coring in the oil field, because the former method yields a larger sample size. However, to retrieve a core sample in the conventional way, you must make a trip to the surface, which is time consuming. The wireline method will become more popular as consultants learn that it is easier to operate. The conventional method uses two kinds of coring heads:

1. A roller-and-cutter head (standard)
2. A diamond head

The roller-and-cutter core heads are only good for 25 to 30 ft, whereas the diamond core head is good for up to 55 ft. The diamond core head will retrieve more length if necessary, and that, in turn, will save you money. If just a small core is needed, the cheaper roller-and-cutter heads are better.

Wireline coring is beneficial only in deeper wells. The wireline is run down the drill pipe and catches the core barrel with an overshot that allows you to bring it to the surface without tripping.

Normally a service hand is on the rig to make up the barrel for the run. He will be able to explain the operating procedure and weight needed for the operation. After the core barrel is made up, it is tripped in the hole slowly to ensure it does not hit the sidewall or dog legs, as this would fill the barrel before it reached bottom. Take your time. Start coring with only a little weight until you get some penetration and then gradually add more weight. Also keep the rpm down until you establish a rate of penetration.

Keep an eye on the pump pressure. When you are on the bottom, the pump pressure will be greater. When you pull off the bottom, it will decrease. The increase in pump pressure will keep the core head clean. If the pump pressure goes up and the core head is still not on bottom, trip the core head out from the hole and check to see if it is already full. The core barrel could also be full or plugged if the rate of penetration decreases. Accurate depth measurements are important in coring operations. The driller should watch for all the signs of a filled barrel and changes in pump pressures to avoid tool damage.

When the core barrel is pulled, it should be done slowly to avoid sucking the core plug back out of the barrel. This is very important for the success of the test. Once the core sample is on the surface, the geologist will take over.

The sidewall core gun is the easiest method to use. The gun is run into the hole with a wireline unit. Quite a few samples at different depths can be obtained with this tool. Most guns come with 40 shots.

The biggest disadvantage to the sidewall core gun is that core samples are small. However, if the samples are wrapped in plastic and stored in airtight containers, and in some cases frozen, they are as usable for evaluating the geology as cores obtained conventionally.

Once the samples are on the floor, the consultant's job is finished as far as core samples go. He will next either run a DST or drill deeper. When drilling deeper, it must be remembered that the core barrel hole is smaller than the core and will have to be reamed. In hard formation areas, the core barrel hole must be drilled out. Once on the bottom of the core hole, pull up and ream down two or three times to widen the diameter of the hole then go back to drilling.

In horizontal wells, coring is not needed at this time; however, once the horizontal drilling begins in hard formations and tight sand areas, then some application may be used. This is new technology that needs to be developed.

**Exercise 8. Make up the summary and the abstract of text A and text B.**

## UNIT 4

## Pipelines and Flow Assurance

### Vocabulary

pipeline – трубопровод
flow assurance – обеспечение потока / безаварийная транспортировка
hydrate – гидрат
wax deposition – отложение парафина
scaling – солеотложение
pigging – пропуск скребка / очистка трубопровода
smart pig – интеллектуальный скребок (дефектоскоп)
hydrate inhibitor – ингибитор гидратообразования
methanol – метанол
monoethylene glycol (MEG) – моноэтиленгликоль
wax appearance temperature (WAT) – температура выпадения парафина
maximum allowable operating pressure (MAOP) – максимальное разрешённое рабочее давление
leak detection – обнаружение утечки
corrosion monitoring – мониторинг коррозии
electromagnetic logging – электромагнитный каротаж
advanced composites – композитные материалы нового поколения
pipeline integrity – целостность трубопровода
choke – штуцер / дроссель
upstream of the choke – выше по потоку от штуцера
differential pressure – перепад давления
relief system – система сброса давления
surge analysis – анализ гидравлических ударов

***Useful speech patterns:***

- *Flow assurance issues include hydrate formation, wax deposition, and scaling.*
- *Hydrate inhibitors (methanol, MEG) are injected upstream of the choke.*
- *The wax appearance temperature (WAT) was measured at X °C.*
- *Pigging operations are performed regularly to remove deposits.*
- *The maximum allowable operating pressure (MAOP) is calculated as...*
- *A smart pig was run to assess pipeline integrity.*
- *Corrosion monitoring is achieved through advanced composites and electromagnetic logging.*
- *Leak detection is based on real-time pressure and flow monitoring.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. The only significant threat to pipeline integrity is hydrate formation downstream of the choke, which can be completely eliminated by injecting monoethylene glycol without any need for mechanical cleaning or pressure monitoring.
2. Flow assurance in pipelines involves managing multiple risks through a combination of chemical inhibitors, mechanical intervention, and system design to maintain pipeline integrity and safe operation.
3. Wax deposition only occurs when the fluid temperature falls below the wax appearance temperature, and smart pigs are used exclusively for removing wax rather than for diagnostic electromagnetic logging or integrity assessment.

## Text A

Maintaining **pipeline integrity** in the hydrocarbon industry requires a constant battle against thermodynamic and hydrodynamic forces that threaten to disrupt production. The discipline of **flow assurance** is dedicated to ensuring the safe and uninterrupted transport of fluids from the reservoir to the refinery. For subsea systems in particular, the stakes are high, as intervention is costly and challenging.

One of the primary risks to **pipeline** flow is the formation of solid deposits. Under high-pressure and low-temperature conditions, light molecules and water combine to form crystalline, ice-like solids known as **hydrate**s. These can agglomerate and completely block a line. To mitigate this, operators inject **hydrate inhibitor**s. The two most common are **methanol** (MeOH) and **monoethylene glycol (MEG)**. While methanol is highly effective, it distributes into all phases (vapor and liquid hydrocarbon), leading to significant product contamination and losses. MEG, though more expensive, has a low vapor pressure and stays in the water phase, making it preferable for systems where regeneration is feasible.

Similarly, the precipitation of long-chain paraffin molecules creates **wax deposition**. This typically occurs when the fluid temperature falls below the **wax appearance temperature (WAT)**. However, recent studies show that deposition can paradoxically occur above the WAT due to factors like shear stripping and molecular diffusion, complicating traditional prediction models. Furthermore, ionic incompatibility between produced water and injected chemicals can lead to **scaling** – the formation of hard mineral deposits inside the pipe.

To manage these deposits, the industry relies heavily on mechanical intervention. **Pigging** involves sending a device through the line to scrape off wax and scale. For routine maintenance, specialized tools like pin-wheel pigs or magnetic cleaning pigs are run to remove deposits without damaging the pipe. For detailed diagnostics, a **smart pig** equipped with sensors (such as electromagnetic acoustic transducers for **electromagnetic logging**) measures metal loss and deformation, providing a critical assessment of **pipeline integrity**.

The physics of the flow also dictates deposition behavior. A **choke** creates a significant pressure drop. Immediately **upstream of the choke**, the pressure is high, keeping hydrates stable. However, the rapid expansion and cooling downstream create the highest risk for hydrate formation. Engineers monitor this **differential pressure** across sections of the line; a steady rise indicates increasing deposit buildup and a growing need for pigging.

Finally, system stability is paramount. Unexpected valve closures or pump trips generate pressure waves known as surges. A **surge analysis** is essential to model these transient forces. If the pressure exceeds the **maximum allowable operating pressure (MAOP)**, the system risks catastrophic failure. Therefore, a properly designed **relief system** (pressure relief valves) is required to vent excess fluid. Additionally, passive systems like check valves prevent reverse flow, while active **corrosion monitoring** probes track the wall thickness over time. As a modern solution, **advanced composites** are now used as repair sleeves to reinforce areas weakened by corrosion or erosion, restoring the pipe's **MAOP** without shutting down the line.

**Exercise 2. Define whether the following statements correspond to the content of the text (true − T; false − F; not stated − NS).**

1. Methanol distributes into all phases (vapor and liquid hydrocarbon), leading to product contamination and losses.
2. Monoethylene glycol (MEG) is always more expensive than methanol but is never regenerated.
3. Wax deposition can occur above the wax appearance temperature (WAT) due to shear stripping and molecular diffusion.
4. Hydrate formation is most likely to occur upstream of the choke, where pressure is low.
5. The only method used to detect leaks in pipelines is electromagnetic logging with smart pigs.
6. A steady rise in differential pressure across a section of pipeline indicates increasing deposit buildup.
7. Advanced composites can restore a pipeline's MAOP without requiring a shutdown.

8. Methanol is less effective than MEG at preventing hydrate formation in all operating conditions.
9. Surge analysis is required by international law for every subsea pipeline over 10 kilometers in length.
10. Pin-wheel pigs are a type of smart pig used primarily for electromagnetic logging.

**Exercise 3. Match the terms in the left column with their definitions.**

| | |
|---|---|
| 1. pipeline | **a.** the engineering discipline dedicated to ensuring the safe, continuous, and uninterrupted transport of fluids from the reservoir to the refinery by managing thermodynamic, hydrodynamic, and chemical risks such as hydrate formation, wax deposition, scaling, and corrosion. |
| 2. hydrate inhibitor | **b.** a sophisticated diagnostic device sent through a pipeline, equipped with sensors (such as electromagnetic acoustic transducers) that perform electromagnetic logging to measure metal loss, deformation, and assess pipeline integrity, as opposed to simple mechanical cleaning pigs. |
| 3. flow assurance | **c.** a long tube or line used to transport hydrocarbons (such as oil, gas, or produced water) from the reservoir to the refinery, often under high pressure and through challenging environments such as subsea regions. |
| 4. methanol | **d.** a device that creates a significant pressure drop in the pipeline; upstream of the choke, pressure is high, keeping hydrates stable, while the rapid expansion and cooling downstream create the highest risk for hydrate formation. |
| 5. smart pig | **e.** a chemical substance (such as methanol or monoethylene glycol) injected into the pipeline to prevent the formation of crystalline, ice-like solids called hydrates, which can agglomerate and block the line under high-pressure and low-temperature conditions. |
| 6. a choke | **f.** a type of hydrate inhibitor that is highly effective but has the disadvantage of |

distributing into all phases (vapor and liquid hydrocarbon), leading to significant product contamination and losses.

**Exercise 4. Find the following words and word combinations in the text and explain what they mean in the given context.**

Wax deposition, WAT, MEG, MAOP, differential pressure, surge analysis.

**Exercise 5. Answer the following questions to the text.**

1. What are the two most common hydrate inhibitors mentioned in the text, and what is a key disadvantage of using methanol compared to MEG?
2. Can wax deposition occur at temperatures above the wax appearance temperature (WAT)?
3. What is the difference between a standard cleaning pig (used for routine maintenance) and a smart pig, based on the description in the text?
4. Why does the highest risk for hydrate formation occur downstream of the choke rather than upstream?
5. What does a steady rise in differential pressure across a section of the pipeline indicate, and what action does it signal to engineers?
6. How do advanced composites contribute to pipeline integrity management, and what advantage do they offer in terms of operational downtime?

**Exercise 6. Read the text. Find in the text and put down key words that can be used to speak about the topic.**

## Text B

In recent years, the demands on pipeline transportation have increased significantly. The service life of a large-diameter pipe manufactured 50 years ago was typically designed for 30 years of failure-free operation. Modern plants ensure failure-free operation for 50 years, and in the near future, for up to 70 years. The primary requirement for pipelines is increasing the operating pressure.

The following problems in the pipeline transportation industry can be identified:

- failure rate on trunk pipelines;
- pipeline diameter;
- increasing throughput capacity;
- high costs of pipeline modernization.

Leading experts highlight the following issues:

- The problem of increasing pipeline throughput capacity. The dependence of oil pipeline throughput on pipe diameter can be illustrated by the following figures: at a diameter of 720 mm – 15 million tons per year; 1020 mm – 45 million tons; 1420 mm – 75 million tons. In our country, the main pipeline network has a diameter of up to 1020 mm. Specific capital investments decrease with increasing diameter;
- Throughput can be increased by raising the pressure inside the pipes, but this requires multilayer pipes, which increases their cost;
- Increasing throughput by laying second lines; pipes are protected from corrosion by various methods, including bitumen-paper coating, polymer films with protective wraps, epoxy and paint films, polyurethane foam, etc.;
- When crossing water obstacles, the pipeline is laid along the bottom. In this regard, problems arise, especially in permafrost zones, desert-steppe regions, etc., because during fluid transportation the pipeline heats up, altering the thermal regime of the soil. In low-temperature zones, conventional steel grades become brittle;
- The problem of reducing the number of personnel remains complex.

To address these problems, research continues on the widespread implementation of automated pipeline operation control systems. Such systems make it possible to ensure optimal pipeline performance according to specified parameters, as well as to maintain records and analyze production and economic activities.

Pipeline valves are designed to control the flow of oil transported through pipelines. Based on their operating principle, valves are divided into three classes: isolation (shut-off), regulating, and relief (safety).

Isolation valves (gate valves) serve to completely shut off the pipeline cross-section. Regulating valves (pressure regulators) are used to change the pressure or flow rate of the pumped fluid. Relief valves (check valves and safety valves) protect pipelines and equipment when the allowable pressure is exceeded, as well as prevent reverse fluid flow.

Gate valves are shut-off devices in which the flow passage is closed by the translational movement of the obturator in a direction perpendicular to the direction of oil flow. Structurally, a gate valve consists of a one-piece cast or welded body equipped with two nozzles for connection to the pipeline (using flanges or welding), and a spindle connected to the shut-off element and operated manually via a handwheel or by a special actuator. The point where the spindle exits the body is sealed using a gland packing. Based on the design of the sealing obturator, gate valves are divided into wedge gates and parallel slide (knife) gates. On trunk oil pipelines, gate valves are equipped with electric actuators.

Pressure regulators are devices used to automatically maintain pressure at a required level. Depending on whether the pressure is maintained upstream or downstream of the regulator, regulators are classified as "pressure-reducing" (controlling outlet pressure) and "back-pressure" (controlling inlet pressure) types.

Safety valves are devices that prevent the pressure in a pipeline from rising above a set value. On oil pipelines, low-lift and full-lift closed-type safety valves are used, which operate on the principle of diverting part of the fluid from the location of overpressure into a special collection header.

A check valve is a device used to prevent reverse flow of the medium in a pipeline. During oil pumping, swing check valves with a disc rotating about a horizontal axis are used. The valves for trunk oil pipelines are rated for an operating pressure of 6.4 MPa.

**Exercise 7. Make up the summary and the abstract of the text.**

# UNIT 5

## Oil Refining and Gas Processing

### Vocabulary

refining – переработка нефти
distillation – перегонка / дистилляция
thermal cracking – термический крекинг
catalytic cracking – каталитический крекинг
reforming – риформинг
hydrotreating – гидроочистка
three-phase separator – трёхфазный сепаратор
heater treater – печь-сепаратор (подогреватель)
desalter – обессоливающая установка
free water knockout (FWKO) – водоотделитель
produced water – пластовая вода (попутно добываемая)
catalyst – катализатор
octane – октановое число
feedstock – сырьё
refinery – нефтеперерабатывающий завод (НПЗ)
gas processing plant (GPP) – газоперерабатывающий завод (ГПЗ)

associated petroleum gas (APG) – попутный нефтяной газ (ПНГ)
liquefied natural gas (LNG) – сжиженный природный газ
sulfur content – содержание серы
light ends – легкие фракции
bottoms – остаток (кубовый остаток)
conversion – конверсия / глубина переработки

***Useful speech patterns:***

- *The well stream enters the manifold and is directed to the three-phase separator.*
- *Thermal cracking at 850°F and 75 psig doubled the yield of gasoline from crude oil.*
- *High-octane gasoline was achieved by catalytic cracking using silica-alumina catalyst.*
- *The desalter reduces the salt content to less than 10 PTB.*
- *Produced water is treated to meet regulatory standards (below X ppm oil-in-water).*
- *The first commercial plant converted natural gas to methanol and then to premium unleaded gasoline.*
- *Belarusian refineries (Mozyr Refinery, Naftan) process domestically produced and imported crude.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. The primary goal of oil refining is to increase the sulfur content of fuels through hydrotreating.
2. Thermal cracking is the most widely used modern technology for converting heavy bottoms into gasoline, and associated petroleum gas is typically flared because no economic recovery methods exist at gas processing plants.
3. Modern oil refining and gas processing use a combination of physical separation, chemical conversion, and impurity removal.

Crude oil and natural gas are complex hydrocarbon mixtures that are generally unsuitable for direct use. **Oil refining** and gas processing transform these mixtures into a wide range of fuels and petrochemical **feedstock**, while removing low-value and polluting components. The following outlines the primary technologies employed in modern **refineries** and **gas processing plants (GPPs)**.

Crude oil is a mixture of many different hydrocarbon molecules of a range of sizes. Smaller molecules vaporize at lower temperatures, so crude oil can be distilled to separate out the different hydrocarbons. This process, known as **distillation**, is the foundational separation technique in any refinery, where crude oil is vaporized and then condensed at different temperature levels to separate fractions like light ends, naphtha, kerosene, and diesel.

Because gasoline and diesel are the most lucrative products extracted from crude oil, refineries use a range of conversion techniques to maximize the production of these fuels. These include:

- **Cracking** (breaking larger molecules down into smaller ones), such as **catalytic cracking**, which uses a catalyst to efficiently convert heavy gas oils into gasoline and propylene.
- **Reforming** (turning smaller molecules into high-octane gasoline components). **Catalytic reforming** uses a catalyst to rearrange hydrocarbon molecules, producing high-octane reformate for gasoline blending.
- **Hydrotreating** (replacing impurities such as sulfur with hydrogen to improve fuel quality). This process is essential for meeting environmental standards for ultra-low sulfur fuels.
- Alkylation (using an acid to produce high-octane gasoline from smaller molecules).
- Blending (mixing different liquids together to produce uniform products that meet regulatory standards).

**Gas Processing**

Natural gas, before processing, consists mostly of methane, with varying proportions of other hydrocarbons (natural gas liquids, or NGLs), carbon dioxide (CO2), sulfur compounds, nitrogen, and water vapor. Gas processing removes some of these non-methane components to improve combustion, prevent corrosion, standardize energy content, and extract valuable NGLs.

The main methods used to remove non-methane components from natural gas are absorption and cooling. A variety of absorbents may be used, including special oils (for NGLs), glycol (for water), and amines (for CO2 and sulfur). Chilling natural gas down to different temperatures allows different components to be removed as they condense into liquids. Cryogenic processing is a common method for NGL recovery. After processing, the gas is deemed "dry" (pipeline-quality) and ready to be shipped to end users, while the extracted NGLs can be fractionated into valuable products like propane, butane, and natural gasoline.

So, the foundational step in any **refinery** is primary **distillation**. Before entering the atmospheric distillation column, the crude must be cleaned and dehydrated. It first passes through a **desalter** to remove salts and solids, then through a **free water knockout (FWKO)** and a **heater treater** to separate any remaining **produced water** from the emulsion. The dehydrated crude is then heated and fed into a distillation column, where it separates into **light ends** (gases, naphtha) at the top, kerosene and diesel in the middle, and **bottoms** (atmospheric residue) at the bottom. This step achieves only physical **conversion**, not chemical.

To maximize the yield of valuable products such as gasoline, heavy **bottoms** are sent to a **catalytic cracking** unit. Unlike older **thermal cracking**, **catalytic cracking** uses a zeolite **catalyst** to break large hydrocarbon molecules into smaller, more valuable ones, significantly boosting both yield and **octane** number.

Simultaneously, the naphtha fraction from **distillation** undergoes **reforming**. In this process, a platinum-based **catalyst** rearranges low-octane straight-chain hydrocarbons into high-octane aromatics. **Reforming** is essential for producing high-grade gasoline blendstock and generating hydrogen, which is used elsewhere in the **refinery**.

Most distilled fractions contain impurities, particularly sulfur. **Hydrotreating** is the key technology for removing these contaminants. The **feedstock** is mixed with hydrogen and passed over a **catalyst** at high pressure. This process converts sulfur into hydrogen sulfide, which is then removed, dramatically lowering the **sulfur content** of diesel, kerosene, and gasoline. Without **hydrotreating**, modern clean fuels meeting environmental standards would be impossible.

Crude oil extraction also releases **associated petroleum gas (APG)**. Unlike non-associated natural gas, APG contains heavy hydrocarbons that must be recovered. At the wellhead, a **three-phase separator** divides the well stream into three outlets: gas, oil, and **produced water**. The wet APG is then sent to a **gas processing plant (GPP)**.

At the **GPP**, the gas is dehydrated, and natural gas liquids (NGLs) are extracted via cryogenic expansion or absorption. These **light ends** (ethane, propane, butanes) become valuable **feedstock** for petrochemicals or are blended into LPG. The remaining dry methane can be sold as pipeline gas or further cooled into **liquefied natural gas (LNG)** for export. Processing APG at a **GPP** instead of flaring it reduces emissions and creates significant economic value.

In summary, a modern **refinery** integrated with a **GPP** maximizes **conversion** of every hydrocarbon molecule – from heavy crude **bottoms** to **associated petroleum gas** – into high-octane fuels, clean diesel, and petrochemical **feedstock**. Through primary **distillation**, **catalytic cracking**, **reforming**, and **hydrotreating**, crude oil is transformed into marketable products. Simultaneously, **APG** is processed in **three-phase separators**, **FWKOs**, **heater treaters**, and **GPPs** to recover valuable **light ends** and produce **LNG**, ensuring both environmental compliance and resource efficiency.

**Refining, Processing, and the Environment**

Refining and processing reduce the environmental impact of oil- and gas-derived fuels by removing harmful pollutants and improving their reliability during combustion. However, refineries and processing plants have their own environmental impacts, with corresponding procedures for minimizing those impacts. For example, modern **hydrotreating** technologies enable the production of ultra-low sulfur fuels that significantly reduce harmful emissions, although the process itself requires substantial energy and infrastructure investments.

**Exercise 2. Define whether the following statements correspond to the content of the text (true − T; false − F; not stated − NS).**

1. Primary distillation is a chemical conversion process that changes the molecular structure of hydrocarbons.
2. A desalter is used to remove salts and solids from crude oil before distillation.
3. Catalytic cracking uses a zeolite catalyst to break large hydrocarbon molecules into smaller ones.
4. Thermal cracking is more efficient than catalytic cracking for producing high-octane gasoline.
5. Reforming rearranges high-octane aromatics into low-octane straight-chain hydrocarbons.
6. Hydrotreating removes sulfur from diesel, kerosene, and gasoline by converting sulfur into hydrogen sulfide.
7. A three-phase separator divides the well stream into gas, oil, and produced water.
8. Associated petroleum gas (APG) contains fewer heavy hydrocarbons than non-associated natural gas.
9. All refineries in the world are currently integrated with a gas processing plant.
10. Cryogenic expansion is one method used at gas processing plants to extract natural gas liquids from APG.
11. Flaring associated petroleum gas produces more valuable products than processing it at a GPP.

12. The text provides detailed cost estimates for building a modern hydrotreating unit.

**Exercise 3. Match the terms in the left column with their definitions.**

| | |
|---|---|
| 1. feedstock | **a.** a catalytic process that rearranges low-octane straight-chain hydrocarbon molecules into high-octane aromatics, producing reformate for gasoline blending and generating hydrogen. |
| 2. cracking | **b.** a refining process that uses an acid catalyst (such as sulfuric or hydrofluoric acid) to combine small, light hydrocarbon molecules (isobutane and olefins) into larger, high-octane gasoline components. |
| 3. reforming | **c.** a physical separation process that heats crude oil to vaporize it and then condenses the vapors at different temperature levels to separate hydrocarbons into fractions such as light ends, naphtha, kerosene, diesel, and bottoms. |
| 4. hydrotreating | **d.** the raw material (such as crude oil, naphtha, or gas liquids) supplied to a refinery, gas processing plant, or chemical unit for conversion into finished products. |
| 5. alkylation | **e.** a vessel that applies heat to an oil-water emulsion to break the emulsion and separate any remaining produced water from the crude oil before further processing (such as in a desalter or distillation column). |
| 6. catalytic cracking | **f.** a refining process that breaks down large, heavy hydrocarbon molecules into smaller, lighter, more valuable ones (e.g., gasoline and propylene). |
| 7. distillation | **g.** a process that uses hydrogen and a catalyst to remove impurities (primarily sulfur, nitrogen, and metals) from petroleum fractions, converting sulfur into hydrogen sulfide to produce ultra-low sulfur fuels. |
| 8. heater treater | **h.** a conversion process that uses a zeolite catalyst to break heavy gas oils into lighter products (gasoline and propylene), achieving higher yield and octane than thermal cracking. |

**Exercise 4. Say what terms are meant by the following descriptions.**

1) APG; 2) GPP; 3) LNG; 4) FWKO.

1. It is an industrial facility where raw natural gas (including associated petroleum gas) is treated and separated into valuable components. At this place, the gas is dehydrated, and natural gas liquids are extracted via cryogenic expansion or absorption. It plays a key role in maximizing hydrocarbon recovery.
2. It is a vessel used in oil and gas production to remove large quantities of free water from the crude oil stream before further processing. In the text, the crude oil passes through it and a heater treater to separate any remaining produced water from the emulsion. This step occurs before the crude enters the desalter and the primary distillation unit, ensuring that the crude is adequately dehydrated.
3. It is a type of natural gas that is released together with crude oil during oil extraction. Unlike non-associated natural gas, it contains heavy hydrocarbons (natural gas liquids) that must be recovered. In the text, it is sent from the wellhead (after passing through a three-phase separator) to a gas processing plant for processing instead of being flared, which reduces emissions and creates economic value.
4. It is natural gas (primarily methane) that has been cooled to a liquid state for easier storage and transportation.

**Exercise 5. Find the following words and word combinations in the text and explain what they mean in the given context.**

remove the contaminants, refining, high-octane fuels, ultra-low sulfur fuels, hydrotreating, three-phase separator, light ends, bottoms, octane number, desalter.

**Exercise 6. Answer the following questions to the text.**

1. What is the purpose of a desalter and a free water knockout (FWKO) before the primary distillation of crude oil?
2. What is the main difference between thermal cracking and catalytic cracking in terms of efficiency and product quality?
3. How does reforming improve the octane number of gasoline components?
4. What undesirable element does hydrotreating remove from petroleum fractions, and into what compound is it converted?

5. Why is associated petroleum gas (APG) sent to a gas processing plant (GPP) instead of being flared?
6. What are the three outlets separated by a three-phase separator at the wellhead?
7. What two methods are mentioned in the text for extracting natural gas liquids (NGLs) from APG at a GPP, and what final product can be made from the remaining dry methane?

**Exercise 7. Make up the summary and the abstract of the text.**

# UNIT 6

## Innovative Technologies in the Oil and Gas Industry

### Vocabulary

artificial intelligence (AI) – искусственный интеллект (ИИ)
machine learning (ML) – машинное обучение (МО)
digital twin – цифровой двойник
autonomous drilling system – автономная буровая система
real-time data analytics – аналитика данных в реальном времени
additive manufacturing – аддитивное производство (3D-печать)
carbon capture and storage (CCS) – улавливание и хранение углерода (CCS)
edge computing – периферийные вычисления
predictive maintenance – предиктивное обслуживание
cloud-based platform – облачная платформа
Internet of Things (IoT) – интернет вещей (IoT)
sensor network – сеть датчиков
automation – автоматизация
remote operations – удалённые операции
subsurface characterization – характеристика недр
geotechnical model – геотехническая модель
repurposing infrastructure – перепрофилирование инфраструктуры
decarbonization – декарбонизация
sustainable – устойчивый
on-demand – по требованию
real-time decision-making – принятие решений в реальном времени
operational efficiency – операционная эффективность

***Useful speech patterns:***

- *Digital twins are transforming traditional practices, shifting from physical surveying to virtual workflows.*
- *Machine learning algorithms are being trained to predict pump failures and optimize production.*
- *Additive manufacturing delivers on-demand, sustainable parts, reducing inventory costs.*
- *The GeoA.I. Framework applies governed automation to convert survey data into engineering-ready insight.*
- *Carbon capture and storage (CCS) is a key pathway for decarbonization, applied in depleted fields and saline aquifers.*
- *Repurposing existing infrastructure for CCS can lower costs by 20% or more.*
- *Edge computing processes data locally, minimizing latency and enhancing real-time decision-making.*
- *The digital oilfield roadmap includes full automation, predictive maintenance, and remote operations.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. Additive manufacturing (3D printing) has failed to reduce lead times for spare parts in the oil and gas industry because logistics in remote locations remains an unsolvable challenge, and most companies still rely on traditional warehousing for critical components.
2. The oil and gas industry is integrating technologies such as artificial intelligence, digital twins, autonomous drilling systems, additive manufacturing, and carbon capture and storage to simultaneously improve operational efficiency, enable real-time decision-making in remote locations, and advance decarbonization efforts.
3. The carbon capture and storage (CCS) is an outdated technology that has no connection to digital innovations, and that repurposing infrastructure for $CO_2$ storage is economically unfeasible compared to building entirely new storage facilities.

The oil and gas sector is undergoing a profound transformation, driven by the dual mandate of **operational efficiency** and **decarbonization**, with companies moving beyond traditional methods to integrate cutting-edge technologies across the value chain. One of the most significant shifts is the integration of **artificial intelligence (AI)** and **machine learning (ML)** into drilling operations. In a landmark deployment at the Permian Basin, Apache Corporation implemented an **edge computing** solution that processes highfrequency sensor data directly at the rig site – at rates up to 100 Hz – rather than relying on distant servers, enabling **real-time data analytics** for drilling optimization while achieving 75-80% cost savings compared to traditional land-based Electronic Drilling Recorder systems and 93-95% savings versus high-end solutions. This architecture aggregates data from multiple sources, including rig PLCs, Pason systems, MD Totco instrumentation, and service company inputs for MWD, mud logging, and cementing operations. Recent research from Saudi Aramco published at the IPTC Summit on AI for the Energy Industry in January 2026 demonstrates that continuous-learning ML models can achieve a Mean Absolute Error of just 1.80 m/h with an $R^2$ of 0.87 for Rate of Penetration prediction while maintaining an average inference latency of $1.5 \times 10^{-4}$ seconds per record, making them suitable for embedded deployment. These advances have paved the way for the **autonomous drilling system**, a solution that combines **automation** with **real-time decision-making** to drill wells with minimal human intervention, relying heavily on **edge computing** where data is processed directly on the rig rather than in a distant data center, thereby reducing latency for critical controls.

The concept of the **digital twin** has evolved from theoretical modeling to enterprise-grade implementation. In October 2025, ABS launched EagleTwin™, a web-based structural digital twin solution specifically designed for FPSO, FLNG, and FSRU operators. This **cloud-based platform** – certified as a SOC Type 2 system, the gold standard in data security – integrates inspection and classification data with any brand of Computerized Maintenance Management System, providing an interactive 3D digital representation of offshore assets that enables more informed **real-time decision-making** for repair and inspection operations while delivering real-time insights into asset conditions and risk factors for early detection of potential issues. Such a **digital twin** is continuously updated via a **sensor network** and the **Internet of Things (IoT)**, allowing engineers to run simulations, conduct **predictive maintenance**, and troubleshoot problems through **remote operations** without stepping foot on site. When combined with advanced **subsurface characterization** and a dynamic **geotechnical model**, operators can visualize reservoir behavior with unprecedented accuracy, reducing geological risks, with all data often aggregated on a **cloud-based platform** to enable global teams to collaborate in real time.

Making **autonomous drilling systems** a reality requires solving a fundamental challenge: connectivity. According to industry expert Lee Ahlstrom of Viasat Energy Services, 85% of surveyed professionals in energy, transport, agriculture, and utilities have struggled to deploy IoT due to connectivity issues in remote areas. **Resilient satellite connectivity** enables precise remote monitoring and control of assets from onshore sites, empowering **Internet of Things (IoT)** devices to control, track, and monitor equipment 24/7. Emerging Narrowband Non-Terrestrial Networks allow a single IoT device to connect to both satellite and cellular networks without dedicated satellite terminal hardware, substantially reducing costs and changing the return-on-investment calculation for operators. This enables uncrewed aerial vehicles for remote inspections of structural integrity, pipeline monitoring, and thermal imaging for leak detection; **predictive maintenance** through continuous data streams from wellheads, pumps, valves, generators, compressors, and environmental sensors; remote diagnostics and intervention allowing experts to diagnose issues and perform software updates without hazardous onsite visits; and autonomous logistics, as demonstrated by the world's longest fully autonomous train system operated by an Australian mining company.

Logistics in remote locations is a perennial challenge, and here **additive manufacturing** (3D printing) offers a solution by producing spare parts **on-demand**. A milestone collaboration between Assembrix, HP, Sparely, and Korall Engineering completed a global series of secure remote printing operations producing certified spare parts for the oil and gas industry, specifically certified polymer valve handwheels for ships and offshore platforms using HP Multi Jet Fusion systems, with Korall working alongside DNV to qualify HP 3D High Reusability PA12 materials as the first **additive manufacturing** polymers for offshore applications. This collaboration achieved lead time reduction from up to 12 months to approximately one week for critical components, $CO_2$ emissions reduction of more than 90% for printed handwheels compared to steel versions due to reduced material usage and shorter transportation routes, encrypted and remotely managed and real-time monitored production builds validating repeatability and traceability and security, with expected production of several thousand 3D-printed parts annually in the Norwegian market alone. The Assembrix platform provides a secure digital framework encrypting and controlling every stage of production, ensuring **on-demand** manufacturing that reduces logistics costs, inventory requirements, and capital lock-in while enabling **sustainable** localized production.

For **carbon capture and storage (CCS)** to succeed at scale, accurate **subsurface characterization** is essential. A comprehensive SPE/SEG paper describes an integrated workflow building 3D basin-scale **geotechnical models** covering approximately 4.5 km of vertical thickness and several hundred square kilometers around existing fields. The workflow integrates Extended Elastic Impedance inversion to derive geomechanically significant impedance volumes describing rock elastic properties (compressional and shear moduli, bulk density); **machine learning** approaches using well logs and EEI seismic attributes to train algorithms establishing relationships between seismic attributes and target log properties (Young's Modulus, Poisson's Ratio, Density) via linear regression; and high-resolution tetrahedral structural models simplified into optimized unstructured meshes where subsurface geometries are preserved with higher resolution in the reservoir and gradually lower resolution away from it. The resulting **geotechnical model** provides comprehensive descriptions of reservoir, overburden, and underburden properties, which is critical for ensuring containment integrity and monitoring $CO_2$ plumes post-injection. This approach also supports **repurposing infrastructure** by characterizing depleted reservoirs for permanent $CO_2$ storage, turning a former liability into an asset for **decarbonization** and making the entire production cycle more **sustainable**. As Andrew Long, PhD, notes in his technical presentations on CCS and offshore wind, accurate subsurface characterization ensures reliable site selection and ranking while facilitating cost-effective deployment of monitoring technologies post-$CO_2$ injection.

In conclusion, what connects all these innovations is a focus on **operational efficiency** through integration. The Apache case study demonstrates how **edge computing** with Python-based analytics transforms unstructured data into structured insights, enabling **real-time decision-making** at the rig site while pushing key parameters to a central OSIsoft PI historian. The ABS EagleTwin platform connects inspection data with CMMS systems, providing operators a complete picture of structural health for **predictive maintenance** and extended asset life. The Assembrix-HP-Korall collaboration shows how **cloud-based platforms** can securely manage distributed **additive manufacturing** across multiple continents. From AI-driven **autonomous drilling systems** to **CCS** projects using **repurposed infrastructure**, technology is making the oil and gas industry smarter, safer, and greener, with edge-to-cloud architectures, satellite-enabled IoT, digital twins, **additive manufacturing**, and embedded AI and ML working in concert to advance the **decarbonization** imperative and deliver a **sustainable** future.

**Exercise 2. Define whether the following statements correspond to the content of the text (true − T; false − F; not stated − NS).**

1. Apache Corporation implemented an edge computing solution in the Permian Basin that processes drilling data at rates up to 100 Hz.

2. Saudi Aramco's research demonstrated that continuous-learning ML models for Rate of Penetration prediction achieved a Mean Absolute Error of 3.50 m/h.
3. The ABS EagleTwin digital twin platform was launched in October 2024.
4. According to the text, Narrowband Non-Terrestrial Networks allow a single IoT device to connect to both satellite and cellular networks without dedicated satellite terminal hardware.
5. The collaboration between Assembrix, HP, Sparely, and Korall Engineering produced certified metal engine blocks for offshore platforms.
6. The text provides specific cost figures for implementing digital twin technology on small onshore drilling rigs.
7. Andrew Long, PhD, argues in his technical presentations that accurate subsurface characterization is irrelevant for carbon capture and storage projects.
8. The text mentions that the world's longest fully autonomous train system is operated by an Australian mining company as an example of autonomous logistics potential for oil and gas.

**Exercise 3. Match the terms in the left column with their definitions.**

| | |
|---|---|
| 1. digital twin | **a.** The use of technology to perform tasks with minimal human intervention, as exemplified by the autonomous drilling system that combines real-time decision-making with edge computing to drill wells without constant manual control. |
| 2. automation | **b.** Three-dimensional digital representations of subsurface geology that integrate data from seismic inversion, machine learning, and structural modeling to describe reservoir, overburden, and underburden properties, essential for ensuring containment integrity and monitoring $CO_2$ plumes in carbon capture and storage projects. |
| 3. decarbonization | **c.** The ability to control, monitor, diagnose, and maintain equipment from an onshore or offsite location without physical presence at the asset site, enabled by satellite connectivity, IoT, digital twins, and edge computing, allowing experts to perform software updates and troubleshooting without hazardous onsite visits. |

| | |
|---|---|
| 4. sensor network | **d.** A virtual replica of a physical asset (such as an offshore platform or a well) that is continuously updated via a sensor network and the Internet of Things (IoT), allowing engineers to run simulations, conduct predictive maintenance, and troubleshoot problems through remote operations. |
| 5. geotechnical models | **e.** A system of interconnected sensors that continuously collects and transmits data from physical assets (such as wellheads, pumps, valves, generators, and compressors) to update digital twins, enable predictive maintenance, and support real-time decision-making. |
| 6. satellite connectivity | **f.** A manufacturing approach where spare parts are produced exactly when needed (typically via 3D printing) rather than stored in centralized warehouses, reducing logistics costs, inventory requirements, and capital lock-in while enabling localized, sustainable production. |
| 7. on-demand | **g.** The process of reducing carbon dioxide emissions, achieved in the text through technologies such as carbon capture and storage (CCS), repurposing infrastructure for $CO_2$ storage, and additive manufacturing that reduces emissions by minimizing material usage and transportation distances. |
| 8. remote operations | **h.** Resilient communication via space-based networks that enables precise remote monitoring and control of assets from onshore sites, empowering IoT devices to operate 24/7 in remote locations where traditional cellular networks are unavailable, often combined with Narrowband Non-Terrestrial Networks to allow hybrid satellite-cellular connections without dedicated hardware. |

**Exercise 4. Find the following words and word combinations in the text and explain what they mean in the given context.**

repurposing infrastructures, machine learning, sustainable, additive manufacturing polymers, predictive maintenance, cloud-based platforms.

**Exercise 5. Say what terms are meant by the following descriptions.**

1) CCS; 2) IoT; 3) AI; 4) ML.

1. A network of connected devices that can control, track, and monitor equipment 24/7. 85% of surveyed professionals have struggled to deploy it due to connectivity issues in remote areas, but emerging Narrowband Non-Terrestrial Networks (satellite-cellular hybrid connectivity) solve this problem by allowing a single device to connect to both satellite and cellular networks without dedicated satellite terminal hardware, substantially reducing costs and improving the return on investment for operators.
2. Systems that optimize drilling operations by analyzing historical and real-time data analytics. Its algorithms adjust drill bit trajectories and equipment parameters to avoid failures, thereby enabling real-time decision-making and paving the way for the autonomous drilling system.
3. A subset of AI that uses algorithms trained on data to make predictions and improve over time.
4. A technology designed to capture $CO_2$ emissions from industrial sources and inject them into deep geological formations for permanent storage. To succeed at scale, accurate subsurface characterization and geotechnical models are essential to ensure containment integrity and monitor $CO_2$ plumes post-injection.

**Exercise 6. Answer the following questions to the text.**

1. What specific cost savings did Apache Corporation achieve by implementing an edge computing solution in the Permian Basin compared to traditional land-based Electronic Drilling Recorder systems?
2. According to the text, what was the Mean Absolute Error (MAE) achieved by Saudi Aramco's continuous-learning machine learning models for Rate of Penetration prediction?
3. In what month and year was ABS's EagleTwin™ digital twin platform launched, and for which types of offshore assets was it specifically designed?
4. What percentage of surveyed professionals in energy, transport, agriculture, and utilities have struggled to deploy IoT due to connectivity issues in remote areas, according to Lee Ahlstrom of Viasat Energy Services?
5. What is Narrowband Non-Terrestrial Network (NB-NTN) technology, and how does it change the cost calculation for oil and gas operators?

6. Which four companies collaborated on the secure remote 3D printing operation that produced certified polymer valve handwheels, and what was the lead time reduction achieved?
7. By what percentage were $CO_2$ emissions reduced for 3D-printed handwheels compared to steel versions, and what two main factors contributed to this reduction?
8. According to the SPE/SEG paper described in the text, what three components are integrated into the workflow for building 3D basin-scale geotechnical models for carbon capture and storage?
9. What is the role of repurposing infrastructure in carbon capture and storage projects, and how does it contribute to decarbonization?
10. According to Andrew Long, PhD, what two specific benefits does accurate subsurface characterization provide for carbon capture and storage projects?

**Exercise 7. Make up the summary and the abstract of the text.**

## UNIT 7

## Scientific Discoveries in Oil and Gas Engineering

### Vocabulary

Darcy's law – закон Дарси
multiphase flow – многофазный поток
relative permeability – относительная проницаемость
porous medium – пористая среда
single-phase flow – однофазный поток
reservoir simulation – гидродинамическое моделирование
governing equation – определяющее уравнение
analytical foundation – аналитическая основа
fluid catalytic cracking (FCC) – каталитический крекинг в псевдоожиженном слое
fluidized bed – псевдоожиженный слой
synthetic oil – синтетическое масло
commercial plant – промышленная установка
well stimulation – интенсификация скважины
shale gas – сланцевый газ
tight oil – трудноизвлекаемая нефть (из плотных пород)
numerical simulation – численное моделирование
finite difference – метод конечных разностей

reservoir engineering – разработка месторождений
oil recovery – извлечение нефти
laboratory experiment – лабораторный эксперимент
analytical solution – аналитическое решение
scientific breakthrough – научный прорыв
pioneering work – пионерская работа

***Useful speech patterns:***

- *Morris Muskat refined Darcy's equation for single-phase flow, making it suitable for the petroleum industry.*
- *Muskat and Milan Meres generalized Darcy's law to cover multiphase flow of water, oil and gas.*
- *The concept of relative permeability was introduced based on experimental results of Wyckoff and Botset.*
- *Muskat's 1949 book Physical Principles of Oil Production provided the analytical foundation for reservoir engineering.*
- *Continuous catalytic cracking was achieved by fluidizing fine silica-alumina catalyst in 1942.*
- *The first commercial plant converting natural gas to gasoline was built by Mobil Oil in 1985.*
- *These discoveries remain relevant to modern reservoir simulation and production optimization.*
- *The generalized flow equation established by Muskat is still the governing equation for multiphase flow in porous media.*

**Exercise 1. Read the text and say which of the following statements expresses its main idea.**

1. The text argues that fluid catalytic cracking (FCC) and synthetic oil production have completely replaced the need for reservoir simulation.
2. According to the text, Henry Darcy's law only applies to multiphase flow in shale gas and tight oil reservoirs, and has no relevance to single-phase flow or laboratory experiments.
3. The text traces the evolution of oil and gas engineering from Darcy's law and single-phase flow to multiphase reservoir simulation.

## Text A

The scientific foundation of modern petroleum engineering began with an understanding of fluid movement through a **porous medium**. The **pioneering work** of Henry Darcy in the 19th century established **Darcy's**

**law**, which describes **single-phase flow** and remains a **governing equation** for the industry. This **analytical foundation** allowed engineers to predict fluid behavior in natural rock formations.

A major **scientific breakthrough** occurred when researchers recognized that reservoir fluids exist in multiple phases. The study of **multiphase flow** introduced the concept of **relative permeability**, which is essential for accurate **reservoir simulation**. Unlike **single-phase flow**, multiphase interactions require **numerical simulation** techniques such as the **finite difference** method, enabling modern **reservoir engineering** to optimize **oil recovery**.

Beyond subsurface flow, surface conversion technologies revolutionized the sector. The invention of **fluid catalytic cracking (FCC)** using a **fluidized bed** allowed heavy hydrocarbons to be transformed into valuable fuels and **synthetic oil**. The first **commercial plant** for FCC in the 1940s marked a turning point in refining efficiency.

More recently, the energy industry has focused on unconventional resources. Advances in **well stimulation**, including hydraulic fracturing, have unlocked **shale gas** and **tight oil** from previously impermeable formations. These developments rely heavily on **laboratory experiment** data and **analytical solution** validation to calibrate field-scale models.

From Darcy’s simple sand column to today’s high-performance computing, each discovery has built upon the last, demonstrating how **scientific discoveries in oil and gas engineering** continue to evolve through integration of theory, experiment, and computation.

**Exercise 2. Match the terms with their definitions:**

| | |
|---|---|
| 1. well stimulation | **a.** a valuable fuel product derived from transforming heavy hydrocarbons through processes such as fluid catalytic cracking (FCC) in a fluidized bed. |
| 2. reservoir simulation | **b.** the movement of a single fluid through a porous medium as described by Darcy's law, representing the simpler foundational case before the study of multiphase flow and relative permeability. |
| 3. synthetic oil | **c.** a fundamental mathematical relationship (such as Darcy's law) that describes the physical behavior of fluids in a porous medium and serves as the |

| | |
|---|---|
| | analytical foundation for reservoir engineering. |
| 4. governing equation | **d.** a set of techniques (including hydraulic fracturing) used to increase the productivity of a well by enhancing fluid flow from the reservoir, particularly applied to unlock unconventional resources such as shale gas and tight oil. |
| 5. FCC | **e.** natural gas trapped within low-permeability shale formations, accessible through advances in well stimulation (e.g., hydraulic fracturing) and representing an unconventional resource. |
| 6. single-phase flow | **f.** a numerical modeling method that uses governing equations and techniques like the finite difference method to predict fluid behavior in a porous medium, enabling reservoir engineers to optimize oil recovery. |
| 7. shale gas | **g.** a refining process that uses a fluidized bed to convert heavy hydrocarbons into valuable fuels and synthetic oil, first implemented in a commercial plant in the 1940s. |

**Exercise 3. Read the text. Find in the text and put down key words that can be used to speak about the topic.**

### Text B

**Morris Muskat** (21 April 1906 – 20 June 1998) was an American petroleum engineer. Muskat refined Darcy's equation for single phase flow, and this change made it suitable for the petroleum industry. Based on experimental results worked out by his colleagues, Muskat and Milan W. Meres also generalized Darcy's law to cover multiphase flow of water, oil and gas in the porous medium of a petroleum reservoir. The generalized flow equation provides the analytical foundation for reservoir engineering that exists to this day.

Muskat was born in Riga, Russian Empire. He came to the United States with his family in 1911, and became an American citizen in 1914. Muskat attended Marietta College and Ohio State University, then taught physics at Bowling Green University. He earned his doctorate in physics from the California Institute of Technology in 1929.

After graduating from Caltech, Muskat joined Gulf Research & Development Company where he started as a Research Engineer and worked his way up to get the position as Chief of the Physics Division, a position he held until 1951. He took a one-year break from Gulf, during World War II, to serve as chief of the Acoustics Division of the Naval Ordnance Laboratory.

In 1951 he became technical coordinator of the Production Department, Gulf Oil Corporation in Pittsburgh, Pennsylvania. Dr. Muskat served as the Vice Chairman of the Petroleum Branch of AIME (now the Society of Petroleum Engineers) in 1953. In 1961 he was promoted to Technical Adviser to the Executive Group of Gulf Oil, a position he held until his retirement in 1971.

Muskat received many honors, including the American Petroleum Institute's Certificate of Appreciation (1965) and Special Scroll (1971), the Society of Petroleum Engineers's Lester C. Uren Award (1969), the American Institute of Mining, Metallurgical, and Petroleum Engineers's Lucas Medal (1953) and honorary (life) membership (1972), membership in the National Academy of Engineering (1983), and Caltech's Alumni Distinguished Service Award (1987). He also has fifteen U.S. patents in various fields of science and engineering.

In his later years Muskat withdrew from professional life and relocated to Pasadena, California, where he died on June 20, 1998, at the age of 92.

Muskat refined the original version of Darcy's equation for single-phase fluid (or homogenous fluid in Muskat terminology) flow by introducing fluid viscosity in the equation, as pointed out earlier by Charles Sumner Slichter, and replacing the hydraulic head by pressure and gravity force. The proportionality constant of the porous medium (which were both unconsolidated sand and consolidated sandstone in the laboratory experiments), using the new refined equation, is called single-phase permeability or absolute permeability, and is now a pure rock property as the fluid viscosity is explicit in the new flow equation. The pressure and gravity force link the refined equation to basic properties in physics, which makes the connection to capillary pressure, and thus Leverett J-function, direct and makes the connection to fluid density visible in the new equation. By these refinements Muskat established a refined flow equation for single phase fluid flow that is valid for water, oil and gas, and thus is suitable for use in the petroleum industry. Muskat and his colleagues verified the new equation by experiments.

Another problem that faced Muskat and his colleagues, is that an oil reservoir has large horizontal dimensions, and production wells are spread all over it. Where will the oil flow? Today the reservoir engineer will use numerical reservoir simulation to answer that question. In the 1930s there were no computers, so Muskat turned to experimental analogues to fluid flow such as heat flow and electric current. Again Muskat refined Darcy's equation by generalizing to three equations for the three space dimensions, as pointed out earlier by Philipp Forchheimer. The single-phase permeability was generalized to be a 3x3 tensor which is usually represented by a diagonal tensor where the vertical permeability differ from the two horizontal permeabilities.

In 1937 Muskat published The Flow of Homogeneous Fluids Through Porous Media. In this book Muskat focused on flow of single-phase fluid in a porous medium, and what type of differential equation can be used to model this flow behavior. Large emphasize is put on discussing results of experimental analogues such as heat flow and electric current. This book also presents and refers to experimental findings made by his colleagues.

An oil reservoir usually has an aquifer below the oil leg, and sometimes also a gas cap above the oil leg. As oil is produced from the oil leg, water and gas will flow into this zone where some oil is still flowing. The operating company may also inject water or gas into the oil reservoir in order to increase oil recovery. The equations for reservoir dynamic must therefore include multi-phase flow of water, oil and gas. As water flow from below and gas flow from above the oil leg, the local mixture of fluid phases will usually only be two phases.

Muskat, with assistance of geophysicist Milan W. Meres (1906–1963), analyzed results from the steady-state and the transient flow experiments of Ralph Dewey Wyckoff and Holbrook Gorham Botset. The experimental results showed that the flow of a mixture experienced an effective permeability that was reduced compared to the single-phase permeability. The reduced permeability correlated non-linearly with volume fraction of the other phase, and the reduction factor (or function) is denoted relative permeability. The formulation is based on Muskat's theory that the porous medium has a local structure of macroscopic size that is defined by the saturations, or volume fractions, of the fluid mixture. Muskat included the new permeability-reducing parameter in the refined single-phase flow equations, and thus established a new differential equation that governs the flow of multi-phase fluids in porous media. The experimental findings of Wyckoff and Botset and the analytical / theoretical findings of Muskat and Meres were published as two coordinated papers in 1936.

In 1949 Muskat published Physical Principles of Oil Production, which advanced the field of reservoir dynamics and reservoir engineering, compared to his 1937 book, and provided the analytical foundation for reservoir engineering that exists to this day.

**Exercise 4. Define whether the following statements correspond to the content of the text (yes, no).**

1. Morris Muskat was born in the United States and became a citizen in 1914.
2. Muskat generalized Darcy's law to cover multiphase flow of water, oil, and gas together with Milan W. Meres.
3. Muskat worked for Gulf Research & Development Company for his entire career without any breaks.
4. Muskat received the Nobel Prize in Physics for his work on reservoir engineering.
5. Muskat introduced fluid viscosity into Darcy's equation and replaced hydraulic head with pressure and gravity force.
6. In the 1930s, Muskat used numerical reservoir simulation to answer questions about oil flow in reservoirs.
7. Muskat's 1937 book focused primarily on multiphase flow and relative permeability.
8. The concept of relative permeability was developed based on experimental results from Wyckoff and Botset and theoretical work by Muskat and Meres.
9. Muskat published his second major book, Physical Principles of Oil Production, before 1940.

**Exercise 5. Answer the following questions to the text.**

1. Where and when was Morris Muskat born?
2. In what year did Muskat and his family move to the United States, and when did he become an American citizen?
3. What degrees and academic positions did Muskat hold before earning his doctorate?
4. Which two colleagues helped Muskat generalize Darcy's law to multiphase flow?
5. What refinements did Muskat make to Darcy's original equation for single-phase flow?
6. Why could Muskat not use numerical reservoir simulation in the 1930s, and what did he use instead?
7. What is the title of Muskat's first major book, published in 1937, and what was its main focus?
8. How did the concept of relative permeability emerge from the experiments of Wyckoff and Botset combined with Muskat and Meres's theoretical work?

9. List at least three honors or awards that Muskat received during his career.
10. In what year did Muskat publish Physical Principles of Oil Production, and why is this book considered significant?

**Exercise 6. Make up the summary of the text.**

## UNIT 8

## Safety Rules in the Oil and Gas Industry

### Vocabulary

hazard – опасность / вредный фактор
risk – риск
safety – безопасность
personal protective equipment (PPE) – средства индивидуальной защиты (СИЗ)
hard hat – каска (защитная)
safety glasses – защитные очки
steel-toed boots – ботинки с защитным подноском
flame-resistant clothing – огнестойкая одежда
hearing protection – защита слуха
respirator – респиратор
confined space – замкнутое пространство
permit-to-work (PTW) – наряд-допуск
lock-out / tag-out (LOTO) – отключение и маркировка оборудования
H2S (hydrogen sulfide) – сероводород
flammable – легковоспламеняющийся
toxic – токсичный
corrosive – коррозионный / едкий
hazard identification (HAZID) – идентификация опасностей
risk assessment – оценка рисков
emergency response – реагирование на аварийные ситуации
muster point – пункт сбора
evacuation – эвакуация
incident – инцидент / происшествие

***Useful speech patterns:***

- *All personnel must comply with the site safety rules.*
- *Safety data sheets (SDS) are available in the control room.*
- *You are required to attend the weekly safety meeting.*

- *Permit-to-work must be obtained before any maintenance activity.*
- *Lock-out / tag-out procedures shall be followed.*
- *H2S is a highly toxic and flammable gas.*
- *Confined spaces present a risk of oxygen deficiency.*
- *The area is classified as Zone 1 (explosive atmosphere).*
- *Hydrocarbon leaks may lead to fire or explosion.*
- *High-pressure lines pose a risk of injection injury.*
- *In case of emergency, proceed to the muster point.*
- *The general alarm is activated — evacuate immediately.*
- *Do not use elevators during a fire.*
- *Report all incidents to the HSE supervisor.*
- *First aid kit and eyewash station are located near the entrance.*
- *PPE must be worn at all times in the operational area.*
- *Hard hats protect against falling objects.*
- *Safety glasses with side shields are required.*
- *You must wear steel-toed boots in the field.*
- *Hearing protection is mandatory in high-noise areas.*
- *Flame-resistant clothing shall be worn by all personnel.*
- *Respirators must be fit-tested before use.*

**Exercise 1. Read the text and express its main idea.**

## Text A

In the oil and gas industry, every operational phase presents a complex array of potential threats, beginning with the fundamental distinction between a **hazard** – defined as any source of potential harm or adverse health effect, such as a **flammable** vapor cloud or a **toxic** gas release – and **risk**, which represents the likelihood and severity of that harm actually occurring. To manage these challenges, the industry relies on systematic **hazard identification (HAZID)** and **risk assessment** processes, as mandated by bodies such as the Occupational Safety and Health Administration (OSHA), the Health and Safety Executive (HSE) UK, and the American Petroleum Institute (API). One of the most critical **hazards** in upstream operations is **H2S (hydrogen sulfide)**, a colorless gas that is both highly **flammable** and **toxic**; because it is heavier than air, it tends to accumulate in low-lying areas and within **confined spaces**, where it can incapacitate workers within seconds. Additional **hazards** include exposure to **corrosive** chemicals used in hydraulic fracturing and the ever-present risk of fire from hydrocarbon vapors.

Before any worker steps onto a rig, a hierarchy of safety controls must be established, starting with engineering and administrative measures. For high-risk tasks, such as hot work or entry into a **confined space**, a **permit-to-work (PTW)** is required – a formal document that authorizes specific activities and lists necessary precautions, including gas testing and ventilation. To prevent accidental energy release during maintenance, **lock-out/tag-out (LOTO)** procedures are strictly enforced to isolate machinery and energy sources. Despite these controls, every facility must maintain an **emergency response** plan; in the event of a gas release, fire, or other **incident**, personnel are required to follow designated **evacuation** routes to a predetermined **muster point**, ensuring full accountability of all workers on site. According to authentic industry standards – specifically API Recommended Practice 54 for occupational safety in drilling operations and API RP 49 for operations involving **H2S** – compliance with these procedures is not optional but forms the very foundation of mitigating **risk** and preventing loss of life.

Finally, while engineering and administrative controls represent the primary defenses, the last line of protection against an **incident** is **personal protective equipment (PPE)**. Standard PPE ensemble includes a **hard hat** for impact protection, **safety glasses** for eye protection, **steel-toed boots** to prevent crushing injuries, **flame-resistant clothing** to protect against flash fires, **hearing protection** in high-noise environments, and a **respirator** or air-supplied breathing apparatus – the latter being especially critical where **H2S** is present or where oxygen levels within a **confined space** may be dangerously low. Through the integrated application of **hazard identification**, **risk assessment**, **permit-to-work** and **lock-out / tag-out** protocols, **emergency response** preparedness, and proper use of **PPE**, the oil and gas industry systematically addresses the realities of **flammable**, **toxic**, and **corrosive** environments to protect its workforce.

**Exercise 2. Define whether the following statements correspond to the content of the text (yes, no).**

1. H2S (hydrogen sulfide) is described as a colorless gas that is neither flammable nor toxic.
2. Personal protective equipment (PPE), including a hard hat, safety glasses, and steel-toed boots, represents the last line of defense against an incident in the oil and gas industry.
3. Lock-out/tag-out (LOTO) procedures are used primarily to authorize hot work and confined space entry rather than to isolate machinery during maintenance.

4. In the event of a gas release or fire, personnel are required to follow designated evacuation routes to a predetermined muster point as part of the emergency response plan.
5. A permit-to-work (PTW) is a formal document used for high-risk tasks, listing required precautions such as gas testing and ventilation before entering a confined space.

**Exercise 3. Read the text. Find in the text and put down key words that can be used to speak about the topic.**

## Text B

Working on an offshore oil rig is a hazardous job even under the best conditions. That's why smart companies put such a strong emphasis on safety. Thanks to a growing "safety first, job second" culture, offshore oil rig fatality rates have decreased steadily over time, according to the CDC.

Still, whether it's the result of exposure to hazardous chemicals, falls, fires, explosions or contact with equipment, oil rig injuries and fatalities continue to occur. It's of utmost importance to consistently remind everyone on the rig – both employees and subcontractors – of maintaining a safe work environment, which includes following all safety rules and regulations and keeping alert to possible hazards.

Leadership who "walks the talk" is always helpful in setting a standard for safety. If management commits to safety, workers will follow suit. Workers won't buy-in, however, if they don't see policies and procedures being followed by their superiors.

All new and transferred rig workers should undergo a mandatory orientation, before being allowed on the rig floor. Such orientation helps employees and contractors become familiar with company and rig operational policies, expectations and worksite rules, thus producing a safer work environment procedures being followed by their superiors.

Following orientation comes training. It includes instruction on the machinery and equipment in use as well as on safety procedures.

All sites require mandatory personal protective equipment (PPE), including safety glasses, hard hats, gloves, steel-toed boots, respirators and fire resistant clothing. A good rule of thumb: If you do not wear the right PPE, you are not allowed on site.

Safety training should always involve a human element. That means facilitating ways for workers to get to know one another. Doing so will build a sense of camaraderie, trust and mutual respect.

Keep floors, pathways and work areas clear of unnecessary items to prevent trips, falls and struck-by hazards. Also, clean up drilling fluids that may collect on the rig floor during pipe handling operations, and display signage that directs workers to emergency and safety equipment, to combat hazards quickly.

Conduct regular maintenance checks of machinery to prevent premature failure, which could present potential hazards, and then repair or replace damaged or inoperable parts and equipment quickly.

Don’t wait for an injury or fatality to occur before you take action to prevent accidents; be pro-active instead.

**Exercise 4. Match the English and Russian equivalents.**

| | |
|---|---|
| a) защитная одежда | 1) expectation |
| b) предотвращать несчастные случаи | 2) fire resistant clothing |
| c) субподрядчики | 3) safety glasses |
| d) доверие | 4) safety training |
| e) защитные очки | 5) prevent accidents |
| f) обучение технике безопасности | 6) subcontractors |
| g) ожидание | 7) possible hazards |
| h) возможные угрозы | 8) trust |

**Exercise 5. Find the odd word out in each line.**

a) hard hats, bore holes, steel-toed boots, respirators;
b) falls, fires, explosions, hazards;
c) remind, pathways, maintain, require;
d) camaraderie, trust, fluids, mutual respect;
e) safety training, PPE, mandatory orientation, equipment, display signage.

**Exercise 6. Answer the following questions to the text.**

1. Why do oil prospecting companies pay so much attention to safety?
2. What accidents may occur in offshore oil rig?
3. What do mandatory orientations provide?
4. What does training include?
5. What is PPE?
6. Why should workers on a building site know each other very well?
7. Why should you keep floor and pathway at workplace clear?

8. What is the meaning of signage at oil rigs?
9. What must be dome with inoperable equipment?
10. What does it mean to be pro-active?

**Exercise 7. Make up the summary of the text.**

## 2.2 Дополнительные тексты для чтения, перевода и интерпретации

**TEXT 1 Pipeline Water Wet Condensate Study**

Currently, there are several different thermodynamic hydrate inhibitors that one has available to choose from. One could choose to use an oxygenate, such as methanol, or a glycol, such as mono-ethylene glycol (MEG) or diethylene glycol (DEG). But what determines the inhibitors hydrate suppression performance, and which one should I choose for my inhibition needs? The primary considerations for an application include:

1. Hydrate Suppression Effectiveness
2. Inhibitor Regeneration Requirements
3. Inhibitor Losses / Product Contamination
4. Inhibitor Cost

Hydrate Suppression Effectiveness

The lower the molecular weight of a thermodynamic inhibitor, the better the hydrate suppression performance. For example, in glycols MEG has better performance characteristics than DEG, and methanol MeOH will outperform ethanol EtOH. In Part 1 of this tip of the month (November 2020 TOTM) provided insight into the relative performance of hydrate inhibitors, and discussed the limitations, pros and cons of the various options. Part 1 demonstrated that for a hydrate depression temperature of 10$^{o}$C (18$^{o}$F) to prevent hydrates formation in our gathering system the required concentration of inhibitor in the liquid water phase using the Nielsen and Bucklin equation is 13 mole %. Figure 1 provides the corresponding weight % of the various inhibitors that would be required for this depression temperature (d). As shown in Figure 1, the inhibitors weight % is a function of molecular weight shown on the horizontal axes.

In this TOTM we will revisit the Case Study of December 2020 TOTM in the application and selection of inhibitor for a gathering system inhibition application. For the same Case Study, we will include the entrained water in the hydrocarbon condensate entering the pipeline.

Revised Case Study

To prepare a hydrate prevention program for the subsea pipeline, let us consider a multiphase subsea pipeline transporting gas and condensate from an offshore production facility to shore. The flow rates and pipeline conditions are provided in Table 1 and Figure 2. The feed condensate to pipeline water-cut is 0.2 volume percent. The solubility of methanol to the hydrocarbon liquid phase is a strong function of both the water phase concentration of inhibitor, but also the hydrocarbon phase composition. The previous case study assumed that the condensate that was separated on the platform was bone-dry when it was pumped into the pipeline with the gas phase. This tip of the month is going to focus on the impact of water-cut in the condensate on the inhibitor injection rates. As with the previous case study, for the methanol injection estimates, we will include both the vapor and liquid hydrocarbon losses.

To determine the impact of the water-cut of the condensate on the inhibitor injection requirement, one needs to calculate the mass of additional water this adds to the pipeline. The additional water is estimated as follows:

► Liquid water rate = (water-cut fraction, $W\text{-}C_x$) (condensate flow rate, $q_c$) (fresh-water density, $\rho_{water}$)

► Liquid water rate = (0.2 /100) (90 $m^3$/d) (1000 kg/$m^3$) =180 kg/d

► Liquid water rate = (0.2 /100) (566 bbl/d) (5.615 $ft^3$/bbl) (62.4 lbm/$ft^3$) =397 lbm/d

The water content of lean sweet natural gas is a function of temperature and pressure and can be estimated from the charts in chapter 6 of volume 1 of Gas Conditioning and Processing. The water content of the gas at the inlet and outlet of pipeline are used to determine the amount of condensed water in the transmission line. The liquid water associated with watercut should be added to the condensed water. The total liquid water is a first key factor that establishes the amount of hydrate inhibitor required. Likewise, the hydrate formation temperature (HFT) is a function of pressure and relative density of gas and can be estimated from the chart in reference. The second key factor is the required depression temperature ($d = HFT - T_{cold}$). The HFT is an important parameter for determination of the depression temperature. The summary of preliminary calculation results is presented in Table 2.

The hydrate inhibitor performance plots that are presented in this tip were developed using the Nielsen and Bucklin correlation presented as equation 1.

(1)

Where: $d$ = depression of hydrate point. °C (°F in FPS)

$x_m$ = mole fraction inhibitor in the liquid water phase

$A$ = constant, -72 (129.6 in FPS)

The third key factor is the required inhibitor weight % in the liquid water phase, $X_R$. From Figure 3 for depression temperature. d = 12.1 °C (22 °F), $X_R$ for MeOH, MEG and DEG are determined and shown in Table 3. The inhibitor concentration in the same phase for all three inhibitors is $X_R$ = 15.6 mole %.

From Figure 4 for depression temperature, d = 12.1 °C (22 °F), and the required ratio of mass of inhibitor in the liquid water phase to mass of condensed water, ($m_I$/ $m_W$) for three inhibitors are determined and shown in Table 3. The required inhibitor rate in liquid water phase, $m_I$, the fourth key factor, can be calculated by equation 2.

(2)

Where: $m_I m_I$ = required inhibitor mass rate in liquid water, kg/d (lbm/d in FPS)

$m_W m_W$ = condensed water mass rate, kg/d (lbm/d in FPS)

$(m_I/m_w(m_I/m_w)$ = Inhibitor effectiveness factor, function of d.

From Figure 4 at the same depression temperature, the required mass ratio, ($m_I$/ $m_W$), for lean MeOH 100 %, MEG 100 wt% and DEG 100 wt%, are 0.33%, 0.63% and 1.08, respectively; and for MEG 80 wt% and DEG 80 wt%, are 0.96% and 1.86, respectively.

The summary of the required inhibitors rate calculations for liquid water phase are presented in Table 3.

Figure 5 and Table 3 present comparison of inhibitors to liquid-water mass ratio, ($m_I$/ $m_W$), requirements for MeOH, MEG and DEG at various lean inhibitor weight %. Figure 5 indicates that methanol with MW=32 is the most effective because of its lowest mass ratio requiring the lowest inhibitor mass rate while DEG with MW = 106 is the least effective because its largest mass ratio requiring the most inhibitor mass rate.

MeOH Losses to Liquid and Vapor Hydrocarbon Phase

Due to low vapor pressure and low solubility in liquid hydrocarbons, glycol losses to vapor and liquid hydrocarbon phases are negligible, and we will assume these to be zero. However, MeOH losses to vapor and liquid hydrocarbon phases are significant and estimated in this tip.

The MeOH losses to liquid hydrocarbon phase can be estimated by our proposed Figure 6 and equation 3.

(3)

Where: $mLF$ = MeOH loss factor from Figure 6, kg MeOH/m$^3$ (lbm MeOH/bbl condensate in FPS)

$q_L$ = condensate rate, m$^3$/d (bbl/d in FPS)

$\gamma$ = condensate relative density

$MW$ = condensate molecular weight

From Figure 6 for depression temperature, d = 12.1 °C (22 °F), the required MeOH loss factor is 0.44 kg/m$^3$ (0.154 lbm/bbl). For a condensate rate of 90 m$^3$/d (566 bbl/d), relative density of $\gamma$ = 0.59 and molecular weight of $MW$ = 55, calculate rate of MeOH loss to liquid hydrocarbon phase by equation 3.

The MeOH losses to vapor hydrocarbon phase can be estimated by our proposed equation 4 and Figure 7.

Where: K = MeOH vapor-liquid equilibrium ratio

$q_S$ = gas rate, std m$^3$/d (scfd in FPS)

$x$ = MeOH mole fraction in liquid water phase

$A$ = conversion factor, $1.35\times10^6$ (84 300 in FPs)

From Figure 7 for cold temperature of 4.4 °C (40 °F) and pressure of 6.2 MPa (900 psia) the K value is 0.0019. For a gas rate of 1.4125 x 10$^6$ std m$^3$/d (50 MMscfd) and MeOH mole fraction of x=0.156, calculate rate of MeOH losses to vapor hydrocarbon phase by equation 4.

The total required inhibitors injection rate to prevent hydrate formation is calculated by equation 5.

(5)

Where: $m_T$ = total required inhibitor rate

$m_I$ = required inhibitor rate in liquid water, this is the inhibitor amount that prevents hydrate formation

$m_{LHC}$ = inhibitor rate loss to liquid hydrocarbon phase

$m_{VHC}$ = inhibitor rate loss to vapor hydrocarbon phase

Table 4 presents summary of total required inhibitors injection rate to prevent hydrate formation. Figure 8 also presents comparison of water phase inhibitor rate compared (blue bars) to total required inhibitors injection rate (red bars) to prevent hydrate formation.Table 4. Summary of total required inhibitors injection rate to prevent hydrate formation.

The inhibitors injection rate in parentheses are for the case of excluding condensate entrained liquid water.

Table 4 and Figure 9 indicate that including the (0.2 vol% watercut) entrained water increases the inhibitor injection rates by 6.7 % for MeOH and 20% for MEG and DEG.

Despite MeOH excellent performance in terms of hydrate suppression, its biggest downfall is its distribution behavior. As shown in Table 4 and Figure 8, methanol was distributed in all three phases of liquid water, vapor and liquid hydrocarbon phases.

In fact, the losses are significantly greater than the rate required in the water phase which results in higher injection rates required as compared to MEG and DEG. For our Case Study the sum of MeOH losses to the vapor and liquid hydrocarbon phases is about 1.6 to two times greater than the required rate of inhibitor in the liquid water phase. The amount of MeOH losses to the vapor phase is a function of pressure, temperature, and mole fraction of MeOH in the liquid water phase. But the amount of MeOH losses to the condensate phase is a function of temperature, mole fraction of MeOH in the liquid water phase, condensate relative density, molecular weight, and concentration of aromatic hydrocarbons. Note that mole fraction of MeOH in the liquid water phase is a function of the required depression temperature.

Once you inject methanol into the pipeline, it distributes to all phases: it is in the gas, the total amount of water (condensed and entrained), and the condensate. This is becoming a significant issue recently. Too much MeOH in the produced water can kill the microbes in the produced water treatment system (and it is toxic to fish so produced water offshore could not go overboard). In addition, MeOH is a petrochemical catalyst poison. Many North American natural gas, y-grade (NGL), and liquid products pipeline tariffs are specifying a maximum oxygenate concentration – or specifying ZERO! In addition, the methanol in the natural gas will slowly kill your very expensive 4A molecular sieve dehydration bed over time if the natural gas is being processed in an expander plant.

Glycols on the other hand have very low vapor pressure, with minimal losses in the vapor phase. In addition, there is very little mutual solubility with liquid hydrocarbons, so the injected glycol remains in the phase that you want it to be in, the water phase. The difficulty of using glycols is that the producer / owner operator needs to own the equipment on both ends of the pipeline so that the glycol can be separated in the plant inlet slug-catcher and inlet separators, so that it can be regenerated and either shipped, trucked or pumped back to the injection points in the gathering system.

Inhibitor Cost

Methanol is cheap in comparison to glycols. As a rough rule of thumb, glycols are roughly three times the cost of methanol. That is why glycols are nearly always regenerated. You only need to invest in the initial chemical costs once. However, methanol is cheap, but you will need to continually buy the amount of chemical you are injecting as it goes down stream and is not recovered.

Summary

This TOTM reviewed a Case Study in the application and selection of inhibitor for a feed gas with water wet condensate in a gathering system inhibition application. The contribution of entrained water in condensate to the inhibitor were considered. Table 4 and Figure 9 indicate that including the (0.2 vol% water-cut) entrained water increases the inhibitor injection rates by 6.7 % for MeOH and 20% for MEG and DEG. If the entrained water in the condensate is not taken into account for the inhibitor injection rates, then there is a strong possibility that hydrates may form in the pipeline because there is insufficient inhibitor present in the water phase. In addition, the pro’s and con’s of oxygenates versus glycols was discussed in more detail.

https://www.jmcampbell.com/tip-of-the-month/2021/02/thermodynamic-inhibitors-part-3-pipeline-water-wet-condensate-study/?utm_campaign=thermodynamic-inhibitors-part-3-pipeline-water-wet-condensate-study&utm_medium=rss&utm_source=rss

## TEXT 2 Oil and gas reservoir

An **oil and gas reservoir** is a formation of rock in which oil and natural gas has accumulated. The oil and gas collected in small, connected pore spaces of rock and are trapped within the reservoir by adjacent and overlying, impermeable layers of rock. Typical reservoirs are ***not*** "pools" or "lakes" of oil beneath the surface, as there are no vast open cavities that contain oil. Oil and gas reservoirs can also be referred to as "hydrocarbon reservoirs".

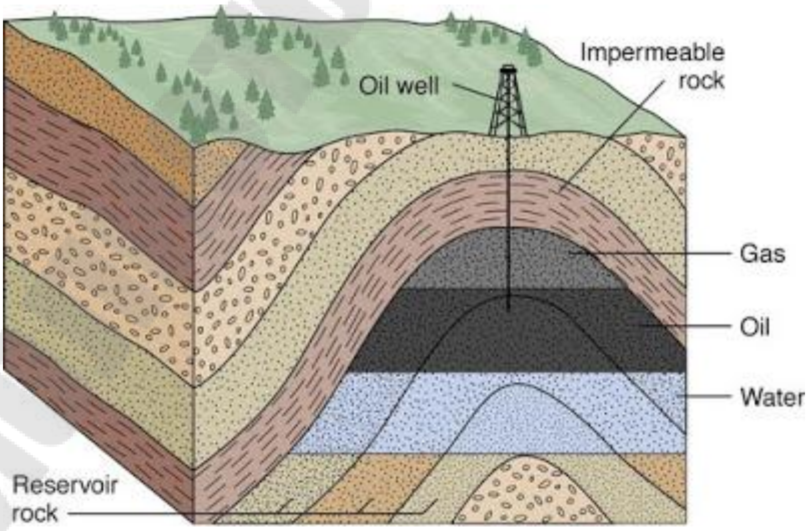

Figure 1. An anticline oil and gas reservoir.

Conventional hydrocarbon reservoirs consist of three main parts: the source rock, the reservoir rock, and the cap rock (Figure 1). The source rock is the rock that contains the kerogen that the oil and gas forms from. The reservoir rock is the porous, permeable rock layer or layers that hold the oil and gas. The cap rock seals the top and sides so that the hydrocarbons are trapped in the reservoir, while water often seals the bottom.

For a reservoir to exist, oil and gas from the source rock must migrate into the reservoir rock, which takes millions of years. This migration occurs because oil and gas are less dense than water. This difference in density causes the oil and gas to rise towards the surface so that they are above groundwater with the gas settling above the oil because of its lighter densities. Migration pathways - a set of well-connected fractures - must exist for this rising to occur.

Reservoir rocks need to be both porous and permeable. This means that there are small pockets of space within the rock where oil or gas can settle and small channels connecting these pockets to allow the oil or gas to flow out of this rock easily when it is drilled. These spaces between grains can develop as the formation of rock occurs or afterwards, usually as a result of groundwater passing through the rock and dissolving some of the cement between sediment grains.

The rock formation must be formed or deformed in such a way to create a trap for the oil and gas. Anticlines are the most common formation shape for this to occur. Anticlines for a rough "A" shape, with the cap rock making the sides of the "A". The fossil fuels accumulate in the peak of the "A" and the bottom is sealed (usually with water), preventing the oil and gas from seeping out and escaping.

https://energyeducation.ca/encyclopedia/Oil_and_gas_reservoir

## TEXT 3 The Influence of Oil and Gas Industry on the Environment

It is impossible to imagine our life nowadays without petroleum products. We use them to fuel airplanes, cars, and trucks; to heat homes; and to make products such as medicines and plastics. Although petroleum products make life easier, finding, producing, and moving crude oil may have negative effects on the environment.

Exploring and drilling for oil may disturb land and marine ecosystems. Seismic techniques used to explore for oil under the ocean floor may harm fish and marine mammals. Drilling an oil well on land often requires clearing an area of vegetation.

Hydraulic fracturing has some effects on the environment. Fracturing rock requires large amounts of water, and it uses potentially hazardous chemicals to release the oil from the rock strata. Faulty well construction or improper handling may result in leaks and spills of fracturing fluids.

However, technologies that significantly increase the efficiency of exploration and drilling activities also reduce effects on the environment. Satellites, global positioning systems, remote sensing devices, and 3-D and 4-D seismic technologies make it possible to discover oil reserves while drilling fewer exploratory wells. Mobile and smaller slimhole drilling rigs reduce the size of the area that drilling activities affect. The use of horizontal and directional drilling makes it possible for a single well to produce oil from a much larger area, which reduces the number of wells necessary to develop an oil resource.

Most oil spills are the result of accidents at oil wells or on the pipelines, ships, trains, and trucks that move oil from wells to refineries. Oil spills contaminate soil and water and may cause devastating explosions and fires. The federal government and industry are developing standards, regulations, and procedures to reduce the potential for accidents and spills and to clean up spills when they occur.

Oil wells are plugged when they become uneconomic, and the area around the well may be restored. Some old offshore oil rigs are tipped over and left on the sea floor in a Rigs-to-Reefs program. Within a year after a rig is toppled, barnacles, coral, sponges, clams, and other sea creatures cover the rig. These artificial reefs attract fish and other marine life, and they increase fish populations and recreational fishing and diving opportunities.

Alternatives to petroleum can include using other “cleaner” energy sources such as renewable energy, natural gas or biodiesel. Some of the alternatives have their strengths and limitations that might impact on the possibility of adopting them in the future.

Renewable energy alternatives also exist. These include solar energy, wind energy, geothermal and hydroelectricity as well as other sources. The production of renewable energy is projected to grow in nearly every region in the world.

Natural gas is also seen as a potential alternative to oil. Natural gas is much cleaner than oil in terms of emissions. However natural gas has its limitation in terms of mass production.

https://www.eia.gov/energyexplained/oil-and-petroleum products/oil-and-the environment.php#:~:text=Exploring%20and%20drilling%20for%20oil,clearing%20an%20area%20of%20vegetation

**TEXT 4 Oil Drilling Crew**

Personnel who operate the drilling rig are called crew. The crew typically consists of roustabouts, roughnecks, floor hands, lead tong operators, motormen, derrickmen, driller and toolpusher. Since drilling rigs operate around the clock, there are at least two or three crews.

A roustabout is any unskilled manual laborer on the rigsite. His responsibilities are ranging from cleaning up location to cleaning threads to digging trenches to scraping and painting rig components. Although roustabouts typically work long hard days, this type of work can lead to more steady employment on a rig crew.

Roughneck is usually a young member of a crew. He typically works under the direction of the driller. He makes or breaks connections as drillpipe is tripped in or out of the hole. On most drilling rigs, roughnecks are also responsible for maintaining and repairing much of the equipment found on the drill floor and derrick.

A floor hand, or member of the drilling crew who works under the direction of the driller to make or break connections as drillpipe is tripped in or out of the hole. On most drilling rigs this work is usually done by roughnecks.

Lead tong operators control the equipment that threads sections of drill casing into the wellbore.

Motorman is the member of the rig crew responsible for maintenance of the engines. While all members of the rig crew help with major repairs, the motorman does routine preventive maintenance and minor repairs.

Derrickman gets his name from the fact that he works on a platform attached to the derrick or mast, typically 85 ft (26 m) above the rig floor, during trips. On small land drilling crews, the derrickman is second in rank to the driller. In a typical trip out of the hole (TOH), the derrickman wears a special safety harness that enables him to lean out from the work platform (called the monkeyboard) to reach the drillpipe in the center of the derrick or mast, throw a line around the pipe and pull it back into its storage location (the fingerboards) until it is time to run the pipe back into the well. In terms of skill, physical exertion and perceived danger, a derrickman has one of the most demanding jobs on the rig crew.

The driller is responsible for the efficient operation of the rig site as well as the safety of the crew and typically has many years of rig site experience. While the driller must know how to perform each of the jobs on the rig, his or her role is to supervise the work and control the major rig systems. The driller operates the pumps, drawworks, and rotary table via the drillers console-a control room of gauges, control levers, rheostats, and other pneumatic, hydraulic and electronic instrumentation. The driller also operates the draw works brake using a long-handled lever. Hence, the driller is sometimes referred to as the person who is “on the brake.”

The toolpusher is usually a senior, experienced individual who has worked his way up through the ranks of the drilling crew positions. His job is largely administrative, including ensuring that the rig has sufficient materials, spare parts and skilled personnel to continue efficient operations. The toolpusher also serves as a trusted advisor to many personnel on the rigsite.

https://www.glossary.oilfield.slb.com/en/Terms/d/drilling_crew.aspx

## TEXT 5 Oil Well Coring

Locating and drilling into oil and gas reservoirs can be a very complicated and dangerous procedure. And as mankind continues to use oil and gas, deeper and more complex wells must be dug to find more pockets of fossil fuels. Oil well coring is a procedure that provides invaluable information to drilling teams and oil and gas companies during the well drilling process.

Oil well coring is a procedure that is meant to remove a small amount of rock sample from within the oil well. This entails using a core bit to drill and remove a cylindrical sample of the rock. The core bit is used with a core barrel and core catcher to drill out a sample that is then brought up to the surface with the core barrel. The core bit has a hole in its center so when the coring procedure is undertaken it produces a small piece of rock.

Because the rock is so tough, the core bit, or drag bit in some cases, uses a PDC* or natural diamond cutting device to cut with. When the cylindrical sample is cut out, it needs to be safely removed from the well. The core catcher device grips the bottom of the rock core. Tension is then applied to the drill-string, and this causes the rock core sample to break away from the rock beneath it. By holding the core sample, the core catcher serves to prevent it from falling away and being lost.

A procedure that has similar goals to coring is sidewall coring. This process differs from standard coring because sidewall coring aims to remove core samples from a hole that has already been drilled. This requires firing a hollow bullet into the sidewall rock formation of the drilled hole to create a core sample. The sample is then removed from the drilled hole with a steel cable. This method is typically used in soft rock formations. The produced samples range in size from 0.75 inches in diameter to 0.75 to 4 inches in length.

Core drilling is used to assess the productivity of oil well drilling. The coring procedure provides valuable information about the makeup of the rock being drilled. Oil well coring is also used during the exploration for oil and gas reservoirs. Obtained core samples hold valuable information. These samples are carefully washed to remove all foreign matter, and then analyzed and labeled. This gives a drilling team information about the depth at which certain rock formations occur at a specific drill hole. Also, oil and gas levels can be estimated based on coring samples.

https://www.sciencing.com/info-7872027-oil-well-coring/

## TEXT 6 THE DIFFERENCES BETWEEN OFFSHORE AND ONSHORE OIL DRILLING

Oil drilling falls into one of two main categories: offshore and onshore. The location of the drilling is the most obvious difference, but the two types vary in other areas, including cost, profits, timelines for drilling and processes.

Both types of drilling have certain advantages over the other, but both are actively used to extract oil to meet the high demands of the world. When you learn how to invest in oil, understanding the differences between onshore and offshore drilling helps you make decisions about your investments a little easier.

As the name suggests, this type of oil drilling takes place off the shore in ocean waters. About 30 percent of the global oil production comes from offshore drilling. Activity take place in all different depths of water, allowing companies to reach a wide number of oil reservoirs.

Offshore drilling in the 1950s generally began in shallow waters about 200 meters deep. In the 1990s, the drilling gradually got deeper and deeper as methods and technologies advanced. Deepwater drilling typically ranges from 400 to 1,500 meters deep, while ultra-deepwater drilling currently reaches depths of up to 3,000 meters. Some companies want to go even deeper, with a benchmark goal of 4,000 meters. Such depths open new possibilities for reaching oil.

Drilling an offshore well is similar to the process onshore — the initial well is drilled and concrete lines the hole. The depth of the hole depends on the location of the oil below the seabed. The oil is pumped up out of the hole using a variety of systems depending on the specific type of platform used for the operation.

A fixed platform anchored to the ocean floor is common for shallow water drilling. Rigid tubes connect the wellhead to the platform to carry the oil to the surface. Deepwater drilling requires a floating platform that uses flexible risers to account for the movement that comes with being on the water. The setup includes risers used to push water and gas down to extract the oil. Other risers carry the oil out of the water. Because of the temperature of the water, the risers are designed to keep the oil warm so it continues flowing freely.

Once pumped, the oil is stored or sent directly to the shore via pipelines, depending on the setup.

Onshore oil drilling encompasses all of the drilling sites located on dry land. Onshore drilling accounts for 70 percent of the worldwide oil production.

Onshore oil production requires the drilling of deep holes down into the earth’s surface to reach the oil below, much like offshore drilling but without the difficulty of deep water between the platform and the oil. Since the ground offers a solid base, the drilling structures and storage areas are built directly on the soil.

A new well first requires the crew to drill below the water table to prevent contamination. The hole is then encased in cement to prevent the oil from seeping into the soil or groundwater supply once extraction begins. Drilling continues to the appropriate depth, based on the specific depth of the oil trap in that area. Once drilled, the well uses liquids pumped into the ground at high pressure levels to remove the oil from the rocks.

The basic equipment is similar for both onshore and offshore drilling. Both require exploratory equipment, pumps, storage facilities and pipelines to drill and collect the oil.

One major difference for offshore drilling is the need for stability. Onshore drilling provides natural stability in the form of the earth’s hard surface. Once anchored to the ground, the rig remains stable and secure.

Offshore drilling presents much more of a challenge due to the shear depth of the water just to reach the earth’s surface. The force the waves, especially in deep, rough waters, presents major stability issues. This activity requires a manmade working surface to hold the drilling equipment and facilities with some type of anchoring to the ocean floor. These jobs use either fixed or floating platforms, depending on the location. The platforms must remain safe and stable even in deep, rough waters.

Offshore drilling often takes much longer to complete than onshore drilling. An onshore well typically takes only a matter of days to drill, meaning
production can begin much faster. An offshore well can take months or years to build. This means an onshore project is up and running much faster than offshore facilities.

Onshore drilling offers more options for storage and transport of the oil after it is extracted from the well. The solid ground surrounding the wells allows for additional processing facilities on site. The location also allows for easy accessibility by trucks and other vehicles, so the oil can easily be transported to other facilities for processing and distribution.

Offshore oil drilling presents more of a challenge to the storage and transport process. This is particularly true for deepwater drilling that takes place far off the shore. The circumstances require special equipment and methods for processing the oil and transporting it after extraction.

Offshore projects close enough to the shore can use a system of pipelines
to bring the oil directly to shore. For deep wells and those far off the shoreline,
barges or tankers process and store the oil until it is taken ashore. These vessels
are called Floating Production, Storage and Offloading units, or FPSO for short.

As the name suggestions, FPSO units can handle the initial processing of the oil while out on the water. The ship is also designed to store the oil until it is offloaded onto a tanker. Each of these vessels holds 2.5 million barrels of oil. Some of these vessels only store and offload the oil. Large offshore production areas may use multiple FPSO units to keep up with the demand of the project.

While offshore operations cost significantly more, they also produce much more oil per day. Shale wells that operate onshore produce roughly 4,000
barrels of oil each day. Because of the lower production, many onshore oil operations involve many wells in one location — sometimes hundreds over a large area. This allows the company to retrieve enough oil to satisfy demand

Deepwater wells have the capacity to produce over 50,000 barrels of oil each day. One well can often access a large reservoir. This greater productivity means offshore drilling sites often have significantly fewer wells with a wider reach than onshore drilling areas.

Offshore wells tend to produce at the same high volume for 10 to 20 years, which can mean tens of millions to hundreds of millions of gallons before the well is done. While the cost to build the wells is much higher, the greater output over time means deepwater wells often see greater profit margins in the end. The payout is higher because the wells produce more oil each day, and the payout continues over a longer period.

Onshore wells typically have a much shorter lifespan. Onshore shale oil wells typically reach about 65 percent of their production in the first year. When paired with the much lower production, the wells produce much less over their lifetime. The tradeoff is the much faster build time compared to offshore production, so it's easier to get new wells up and running when new onshore sources are discovered.

## TEXT 7 HOW DO OIL AND GAS FORM?

It's important to understand where oil comes from. The oil drilled today started millions of years ago as tiny living organisms. It mostly happens in sediment deposits that collect in depressions at the bottom of the ocean. When phytoplankton, algae and other marine organisms die, they drift to the seafloor, collectively forming sedimentary drifts of decaying organic matter. These get lodged in places where tectonic plates are subsiding. Proteins, lignin and cellulose break down very quickly into amino acids and sugars; they turn into sludge. As more and more sediment layers accumulate, the bottom layers get compacted by the increasing pressure bearing down on them. This in turn ramps up their temperature. Over geologic time, turning up the heat catalyzes the chemical processes that cause extremely heavy and complex molecules called kerogens to assemble from the dismantled components of organic molecules. These kerogens, along with long-lasting lipids and scant leftover bits of cell wall, make up the raw material that will turn into petroleum. When a kerogen layer gets buried one to three miles deep, the temperature climbs to the 120 to 300 degree-Fahrenheit range, and the pressure escalates.

Over the course of several or tens of millions of years, the carbon bonds in kerogen and the other molecules break apart. This process, called "cracking," produces the simple hydrocarbon molecules that we call petroleum. The expansion that occurs when the kerogen becomes a gas or liquid makes it like a pressure "cooker". Eventually the surrounding rock fractures and that's when we get expulsion. The oil migrates out of the source rocks to places where the pressure is lower.

Like oil, natural gas is a product of decomposed organic matter, typically
from ancient marine microorganisms, deposited over the past 550 million years. Sealed off in an oxygen-free environment and exposed to increasing amounts of heat and pressure, the organic matter underwent a thermal breakdown process that converted it into hydrocarbons.

The lightest of these hydrocarbons exist in the gaseous state under normal conditions and are known collectively as natural gas. In its pure form, natural gas is a colorless, odorless gas composed primarily of methane. Methane, the simplest and lightest hydrocarbon, is a highly flammable compound consisting of one carbon atom surrounded by four hydrogen atoms (chemical formula: CH4). Once natural gas forms, its fate depends on two critical characteristics of the surrounding rock: porosity and permeability. Porosity refers to the amount of empty space contained within the grains of a rock. Highly porous rocks, such as sandstones, typically have porosities of 5 percent to 25 percent, giving them large amounts of space to store fluids such as oil, water, and gas. Permeability is a measure of the degree to which the pore spaces in a rock are interconnected. A highly permeable rock will permit gas and liquids to flow easily through the rock, while a low-permeability rock will not allow fluids to pass through. After natural gas forms, it will tend to rise towards the surface through pore spaces in the rock because of its low density compared to the surrounding rock. Most of the natural gas deposits we find today occur where the gas happened to migrate into a highly porous and permeable rock underneath an impervious cap rock layer, thus becoming trapped before it could reach the surface and escape into the atmosphere. There are two general categories of natural gas deposits: conventional and unconventional. Conventional natural gas deposits are commonly found in association with oil reservoirs, with the gas either mixed with the oil or buoyantly floating on top, while unconventional deposits include sources like shale gas, tight gas sandstone, and coalbed methane.

The purpose of oil drilling is to reach trapped oil below the rocky layers.
The drilling activities dig deep into those layers to extract the oil safely. This goal is the same, whether the drilling takes place onshore or offshore. Trapped

oil is found in various places around the world, including under the bed of oceans, which is why we have offshore drilling facilities. Oil companies don't begin drilling in random spots. Geologists use many techniques to discover potential oil traps under the earth's surface to help the company target the drilling activities, which maximizes profits. The discovery methods are used for both onshore and offshore drilling.

Methods of finding oil traps include:

Physical examination: Studying the physical characteristics of the area can help identify the conditions most likely to indicate a trap. This was previously
one of the primary methods, but geologists now have many other ways to assess the potential using modern technology.

Aerial photos: In some cases, aerial photos are used to help identify potential drilling areas. The photos can provide a different perspective to shed
light on the search for oil.

Satellite images: A similar method uses satellite images of the land.

Gravitational studies: The gravitational field tends to change in areas above flowing oil. Geologists use magnetometers to spot changes in the gravitational pull. The changes are often minor, but this method can be a big help in finding new sources of oil.

Scent detection: Electronic devices called sniffers can sometimes detect the scent of hydrocarbons, which can indicate oil in the area.

Seismology: When using seismic surveys, geologists send shock waves down into the earth and interpret the reflection to assess the possibility of oil below the ground. These shock waves are controlled to ensure safety for the surrounding ecosystem.

## TEXT 8 WHAT ARE OIL AND GAS?

This reader covers basic information about oil and gas and the industry that extracts them. It is intended to give a basic understanding to those who aim to promote better use of revenues from oil and gas.

Oil and natural gas are hydrocarbons, strings of carbon and hydrogen formed from organic material compressed over millions of years. Generally, oil and natural gas are both referred to as petroleum. They are often found together. If a reservoir (area underground) has only gas and no oil, it is called non-associated gas. If a reservoir contains both oil and gas, the gas it contains is called associated gas.

The oil and gas found in the ground come in different grades or qualities. The primary way to describe the quality of oil is in terms of its sweetness and heaviness. The sweetness of oil refers to the amount of sulfur in the oil. Oil with less sulfur is sweeter and requires less processing before use, and is therefore more valuable. The heaviness of oil refers to its density. Lighter crude can be refined into higher value products, such as the gasoline (or petrol) used by car owners. Heavier crude flows more slowly and has more unwanted chemicals that must be refined out. The American Petroleum Institute (API) has created a degree-based gravity scale that compares the relative density of various crudes. Light crude is measures above 31.1o API while heavy crude measures below 22.3o API. Refining What comes out of the ground is not often a form of petroleum that can be used right away. For it to be the fuel that can go into a car or converted into plastics, it must go through a process of refining. Refining is a chemical process of heating and cooling that isolates the chemicals that are most useful in the end product. This reader is intended for use in conjunction with the Natural Resource Charter.

Natural gas is mostly methane, with some other contaminants. It is also described as either sweet or sour depending on the amount of hydrogen sulfide in the reservoir.  When gas is refined, leaving mostly methane, it is called dry gas. Often natural gas is condensed into natural gas liquids, such as propone and butane. The British thermal unit (BTU) is the measure for the energy output of gas. While gas burns cleaner and is considered to have less destructive environmental impact upon use than oil or coal, the challenges associated with storage and transport can make it more expensive.

Reserves of oil are generally measured in tons or barrels of oil. Production quantities are abbreviated using “bbl” (or barrels of oil per day, bbl/d or bpd). One ton is approximately between six and eight barrels of oil. Reserves and production quantities of gas are measured in cubic meters (m3) or standard cubic feet (scf).

HOW DO COMPANIES GET OIL AND GAS OUT OF THE GROUND? The process of getting oil and gas out of the ground begins with exploration and appraisal. Oil and gas are found under the ground in reservoirs that are sealed but connected to other chambers of oil and gas underground. When a reserve of oil is found, the company will often produce a description of the quality of the oil and the estimated amount measured either by volume (barrels) or by weight (tons). The company may also classify some of the contents as proven reserves. Proven reserves are oil finds that are considered commercially viable—that is, the company is at least 90 percent certain that it would make money getting petroleum out of the ground and taking it to market. If oil is held in a probable reserve, then the company thinks there is at least a 50 percent chance of recovering the oil. Unprovable or possible reserves are those with a 10 percent to 50 percent probability of profitable extraction. The word resource is used to refer to all fields within a country, including those that may not be economically feasible to extract.

Once the reservoir is deemed commercially viable and the company has been granted legal authorization to tap it, the company will often begin digging test wells. These wells will give more information about viability and can indicate what type of equipment is best for production. Production, the next phase after exploration and appraisal, is the process of getting the oil and gas out of the ground. This can occur in three different ways. Primary recovery efforts are when the oil will flow to the surface under its own pressure. When water or gas are injected into the reservoir to lift the oil, recovery is considered secondary. Tertiary, or enhanced, removal happens when chemicals are put into the well. The production rates of wells vary greatly depending on the geology and technology used. Rates are usually measured in barells per day. The lifecycle of a typical well will have a build-up period, peak, and then decline.

The final phase of an oil project is decommissioning and abandonment. This phase requires closing the reservoir, removing equipment, and restoring the environment to is previous state.

The cost of extraction varies greatly depending on the type of oil and its location. Generally offshore oil is much more costly to extract than onshore oil.

WHO ARE THE KEY PLAYERS IN THE INDUSTRY? Countries with large reserves of oil and gas have always been very powerful players in the industry. The Organization of Petroleum Exporting Countries (OPEC) formed in 1960 as five countries collaborated to get the best price for their oil. Today, OPEC represents 12 countries, which together control 80 percent of the world's proven reserves and one-third of production. Often countries make agreements, or contracts, with companies to help extract the oil and bring it to market.

National oil companies (NOCs), oil companies that are primarily or completely owned by the government, are some of the biggest players. Saudi Aramco, for example, is the largest oil company in the world. In addition to being involved in extraction, many national oil companies are also involved in regulation of the industry, commodity trading, and quasi-fiscal expenditures. For more on NOCs, please refer to reader on state participation and state-owned enterprises.

International oil companies are privately owned by shareholders, instead of governments. The six largest supermajors companies are ExxonMobil, BP, Royal Dutch Shell, ConocoPhillips, Chevron/Texaco, and Total. These large oil companies cover all aspects of the industry value chain from extraction through distribution. They tend to be risk averse, preferring to engage in projects where there are more established legal regimes and higher probability of successful extraction. Supermajors own a small share of reserves compared to NOCs, but their profits are still very large, often comparable to the GDPs of many medium-sized countries.

Smaller, multinational companies like Occidental Petroleum and Anadarko Petroleum still have billions of dollars in capital. These tend to be more innovative and develop a technical expertise in one area of extraction, such as deep-water drilling.

Another type of company involved is a service provider. These companies supply specialized services for the larger companies, such as rigs, pipes, seismic surveys, and rig operators. Examples include companies like Halliburton and Transocean. Though they are smaller than the supermajors, some are still very large companies. Halliburton, for example, had revenue of $32.9 billion in 2014 and employs over 75,000 people.

WHAT ARE THE MAJOR TRENDS IN THE INDUSTRY? At the moment, in early 2015, the price of oil is dropping rapidly. Price fluctuations in oil and gas can impact the direction of the industry because costs are different at different extraction points. Shale oil, for example, can be very costly to produce and may become less commercially viable if prices continue to drop. Countries with large production fields and large companies can more easily ride price shocks without having to make drastic changes to their activities.

Shale gas refers to reservoirs of gas that are trapped in rock formations that are less permeable. Removing gas from this formation requires a process called hydraulic fracturing, or fracking. Fracking involves pumping a mixture of water, sand and chemicals into a well under high pressure. Shale gas production has become extremely controversial due to its potential social and environmental impacts. Technological innovations during the years when oil prices were high made shale oil and gas more commercially viable to extract. The production of shale hydrocarbons has altered the market structure, and increased the production capacity of the United States, Canada, and Russia. However, the drop in oil prices in 2015 has already led to a downsizing of this industry, especially in the United States.

Amid fluctuating prices, the global demand for energy, including oil and gas, is increasing. While alternative forms of energy are becoming more popular, there are still strong indications that the use and production of oil and gas will continue. Though industrial energy efficiency is increasing, the demand for transportation and increasing population means there is an overall increasing need for energy.

Oil and gas are highly concentrated geographically. As of 2011, the Middle East held 48 percent of the world’s known oil reserves.

Improvements in exploration technology and economic stability in Africa have prompted oil and gas companies to begin exploring where they have not looked previously. As a result, since the early 2000s there has been an increase of discoveries throughout Africa.

## TEXT 9 Logging the Well and Accompanying Problems

When you "TD a well" (drill to total depth), the next step is to "log the hole" with electrical, nuclear, and side-wall core samples. The purpose of logging is to determine the basic characteristics of various potential pay zones in the borehole.

Oil and gas are not found in pools or caverns but are dispersed throughout the reservoir rock. Not all rocks will hold fluids. In order to hold oil or gas, the rock must have spaces between the rock granules. The ability of rock to contain fluids is measured by its open pore space and is called "porosity." It is measured in percentages. If the porosity is 20%, it means that 20% of the rock volume is pore space available for fluids and 80% is solid rock.

It is not enough for a rock to contain oil or gas. In order for oil or gas to be recoverable, it must be able to flow into the wellbore. The fluids can flow only if pore spaces are connected. The ability to flow is called "permeability" and is measured in millidarcies, often abbreviated md.

The ability of oil or gas to flow also depends on the pressure in the zone, which provides the driving force to push the fluids into the well. It is important in analyzing the potential zone to know this pressure. This is measured in pounds per square inch, abbreviated psi.

It is also important to know the type of fluids in a zone-whether they are hydrocarbons or salt water. Salt water is a good conductor of electricity, and hydrocarbons have a high resistance to electricity. Therefore, tests are run to determine the "conductivity" and "resistivity" of a formation. High conductivity indicates salt water and high resistivity indicates oil and/or gas.

Since the consultant is not hired to analyze the logs and samples, you should not make any suggestions unless you are trained in log analysis. Your only concern is to get the logging device to the bottom and back up again. You are paid to drill a hole, not to analyze samples. This chapter will touch on the kinds of logs there are, how they work, the problems of running a log, and in particular, the problems of getting stuck in the hole. There are many combinations of logs to run and different types of data to analyze.

### Induction Tools

The first logs run are generally run with induction tools. These tools measure the resistivity of the formations and thereby determine the location of hydrocarbons in the well. They will operate in temperatures of up to 350°F and pressures of up to 15,000 psi.

**Porosity-Lithology Logs**

These logs are the density, sonic, gamma ray, and neutron logs. Hydrocarbons affect these logs and are recorded on the drilling log. These tools are rated at 350°F and are used in most wells.

These logs measure the amount of pore space in the hydrocarbon-bearing formations. From this the geologist can estimate the number of barrels in the reservoir thereby deciding if the well has commercial potential. These logs are run by the sonic, density, and neutron logs. The density and neutron tools have radioactive sources on them, and much care should be taken not to get them stuck, since the federal government may require their removal.

**Dipmeter and Directional Logs**

The dipmeter is run to give a correlation to other wells and to determine the formation dip. The survey part of this tool will give hole deviation and true vertical depth (two). A caliper survey is also part of the system and is used to determine cement values (amount of washout in borehole). When the logging truck arrives on location, be sure the log engineer has the correct tools. Before any operation starts, sign for tool protection insurance. This can be important if the tool gets stuck and cannot be fished out. The tool protection insurance costs about $40 compared with the $30,000 to $40,000 cost of some tools. With insurance you are usually required two trys to fish a tool after which you have the choice of continuing to fish or of setting a plug, kicking off, and drilling a new hole.

In some cases the U.S. Geological Survey requires that nuclear logs be fished out, which could become quite expensive to the operator.

The consultant should be on the log truck until the tool reaches the bottom; then his job is done. Going to the bottom with the log can be difficult sometimes because of bridges and trash in the hole. It is important to clean and condition the hole and the mud before the logs are run.

If the tools hit a bridge you should try to work them through it by playing them up and down. If this does not work the tools through the bridge, you will have to pull them and go back in the hole with the bit and clean out the hole. This can be quite expensive and time-consuming.

If the tool sticks coming out of the hole, have the engineer inform you before he pulls too hard on the tool. The tool has a special pull-off socket that will allow the wire to come off the tool, leaving the tool in the hole.

Before you pull off the tool, put some pull on the tool and let it set. Sometimes the pull will free the tool. Never pull off the tool until the office is notified. Put some tension on the tool and call in. Sometimes by the time you call, the tool will have come loose and the cable and tool will be on their way to the surface.

If the decision is made to pull off the tool, put maximum pull weight on the tool and call a fisherman. Find out how long it will take for him reach your location and then go work with the tool. Pull off the tool just before the fisherman arrives and get ready for him.

Since the tool has a special surface for fishing, fishing usually is no problem. Sometimes there is a problem getting over the top of the tool if it is against the wall. When this happens, special hook wall joints will be needed to get the fish. Another system of fishing is to use the wire to guide the fishing tools over the fish. This method is expensive because the wireline must be cut.

Most tools get stuck because the tool fails to close properly and one of the pads becomes stuck against the wall.

The tool man will sometimes try to blame the stuck tool on the hole conditions, but before you pay for the run, examine the tool. If the pads are not all in the closed position, then tool failure caused the tool to stick and you should not pay for the misrun.

Although most logging companies keep their tools in good condition, many still fail. If a tool has not been reconditioned, it is especially subject to failure. Logging failures are common so expect them, and do not let the logging engineers put the blame on hole conditions. Always look their tools over carefully.

In the horizontal well logs are run to correlate between wells in the area to find the right spot to begin horizontal drilling. Another log that is used by some geologists is the cibal log. It shows fractures in the wellbore, which lets the geologist determine the best entry spot and gives him an idea of how well the well is fractured. The cibal is very expensive, and some operators do not use it.

## TEXT 10 The Horizontal Directional Driller And MWD Tools

One thing essential to horizontal drilling is the development of horizontal drilling tools. Directional drillers have been used offshore for years, so the basic technology has been available. The first horizontal well really shook up most old-timers. The thought of horizontal drilling seemed ludicrous. Most people did not realize that the horizontal well had a large curve before it became flat (another word ed to mean horizontal). The area of the curve is large enough that the drill pipe will bend around the curve and can also be rotated.

The directional driller normally works for a company that furnishes tools for the project. The day-rate cost is very h. Directional drillers are now in such demand that companies are selling them at a premium. Sometimes you have to sign a year contract just to guarantee the tools and the individual you want on location.

The influx of more tools and smaller companies will put horizontal drilling back in competition and lower the prices. As of the writing of this book, it is still hard to get a fair price. The well needs to be planned out in advance in order to shop for good prices and get a good deal. Of course, wells that are promoted through phone rooms do not create a cost concern, since the cost is just passed on to the investor. That also is a factor in the high prices. Established oil companies that use most of their own money to drill the well have to operate more efficiently so the well will make a profit. One great advantage of the horizontal well is that an investor has a better chance of a return on his money because of the many producing zones encountered. A vertical chalk well can only deal with one fracture.

In choosing a directional drilling company, get some bids and shop around. Choose a directional driller that has had experience in curve and horizontal drilling and has been successful. A good directional driller can make or break your operation. Once a well goes in the horizontal direction, the consultant's main job is to keep the well from blowing up and to work the PWD system. The directional part is really out of his hands, but he should stay on top of what the driller is doing. If it looks as if something is wrong, ask the driller and call the office engineer and give a quick report. Since the business is booming, there are many fast-trained directional drillers in the field. As more people are trained and acquire experience, things will improve.

One thing to watch for is the directional driller using the brake. Directional drillers want to move their tools, but they do not have the insurance to do this. If they hurt someone, the consultant will also be dragged into the lawsuit for not watching his business. The driller from the rig is the only one allowed to touch the brake. The directional driller using the brake is one of the serious things to watch for, for the safety of the operation, since he is not familiar with your rig. Any good rig driller will tell you that it takes a couple of days to adjust to a new rig.

The directional driller should have his own phone, or else your phone will be tied up all day.

The MWD (measurements-while-drilling) equipment is the best invention made for directional wells. The equipment is very expensive and is run by batteries. By comparison, the steering tool comes from the Dark Ages of drilling. The equipment gives a reading so that the directional driller knows where he is in the well. The advantage is that no wires are needed to take a reading, unlike the method using steering tools. This equipment can run four to six days on a set of batteries. After the batteries go dead, a wireline can be dropped and attached on the top of the MWD and retrieved. Then it is sent back down the hole to operate another four to six days. It is a first-class operation. The only problem is that the drilling must be stopped to get a reading. However, this is not a long time. The MWD tool costs from $50,000 to $65,000. Be sure to sign up for tool protection on the rental agreement. This tool protection will pay about half of the cost.

Also sign up for tool protection on all downhole motors; this will save you one-half the retail cost.

## 2.3 Дополнительные тексты для аннотирования и реферирования

### TEXT 1 Upstream, midstream, and downstream oil and gas industry

Upstream industry is the portion of the oil and natural gas industry that is responsible for finding crude oil and natural gas deposits, along with producing them. Upstream industry is sometimes known as the exploration and production or E&P sector. This part of the petroleum industry includes all activities that happen out in the field including drilling wells, trucking supplies, and mining oil sands. In addition, it includes planning and preparation—including environmental studies and engineering plans.

The different sectors within the upstream industry include:

- Offshore drilling
- Oil sands mining
- Supply and service
- Manufacturing
- Seismic surveys
- Geological surveys
- Reclamation

There are several environmental impacts that can be connected to various upstream petroleum activities. There are a wide variety of emissions released into the atmosphere as a result of activities such as flaring. This reduces air quality and increases greenhouse gas emissions. Some of these emissions include benzenes, particulate matter, acid emissions, methane, and carbon dioxide. 2013 estimates report that the upstream oil and gas sector contributed 20% of the sulfur oxide (SOx) emissions, 23% of the nitrogen oxide emissions (NOx), and 29% of the volatile organic compound emissions in Canada. Moreover, water quality and negative environmental effects from land use are a concern with upstream industry. The use of fracking fluids when drilling wells is a concern in terms of groundwater contamination and the extensive water use in oil sands extraction is potentially problematic. As well, the disruption of habitats can arise from development of extraction sites.

Midstream industry is the portion of the oil and natural gas industry that processes, stores, and transports products such as crude oil, natural gas, natural gas liquids, and sulfur. Midstream industry is responsible for linking far-spread petroleum producing areas and population centers where consumers are located. Transmission pipeline companies are included in the midstream petroleum industry. In places like Canada with extensive oil sands extraction, the process of upgrading bitumen to synthetic crude is a part of midstream industry.

The different sectors included in midstream industry are:

- Pipelines
- Transportation
- Upgraders and refineries

There are several environmental impacts that can be connected to various midstream petroleum activities. The most apparent impacts are the ones associated with the transportation of goods. Since the midstream industry relies heavily on fossil fuels to transport oil and gas, there is an associated reduction in air quality and increase in greenhouse gas emissions. These greenhouse gas emissions include methane (the main component of natural gas) and carbon dioxide. There is also a higher risk of accidental leaks, spills, and explosions from pipelines, railroads, and ship tankers used to transport petroleum products that can harm the environment. As well, the development of infrastructure necessary to make this possible disturbs wildlife habitats.

Downstream industry is the portion of the oil and natural gas industry that is responsible for the refining, distributing, and retail of petroleum products. This portion of industry includes oil refineries, petrochemical plants, petroleum products distributors, and natural gas distribution companies. Downstream industry provides numerous products such as jet fuel, gasoline, diesel, synthetic rubber, plastics, pesticides, pharmaceuticals, natural gas, and propane.

The different sectors within the downstream industry include:

- Distributors
- Retail outlets (like gasoline stations)
- Production plants

There are several environmental impacts that can be connected to various downstream petroleum activities. Distribution activities can be heavily reliant on fossil fuels, which can result in more greenhouse gas emissions to the atmosphere. These emissions include carbon dioxide, sulfur oxides (SOx) and nitrogen oxides (NOx); along with occasional releases of hazardous materials such as solvents or groundwater contamination from production. 2013 estimates report that the downstream oil and gas sector contributed about 5% of the sulfur oxide (SOx) emissions, 1% of the nitrogen oxide emissions (NOx), and 2% of the volatile organic compound emissions in Canada. These values are significantly lower than the emissions for upstream industry. Moreover, since distribution is a component of downstream oil and gas, the possibility of leaks exists. Gasoline stations are particularly notorious for emitting volatile organic compounds.

## TEXT 2 Finding the horizontal zone to drill

When a horizontal well is being drilled, finding the right zone to drill is very important (see Figure 21-1). This is done in several ways. After logging the intermediate hole, some operators just correlate with logs from other wells in the area. This is cheaper, but not as accurate, and in some cases it causes problems. The best way to find the zone is to drill below the estimated zone depth and then run a set of logs to pick the tops of the zones.

The procedure is as follows: First, after nippling the stack, pick up the drill string and follow steps 36 to 42 of the procedures for horizontal drilling (in Chapter 4). After the well is logged, a zone is chosen and a special kickoff plug is set. This plus has some sand in it, so the curve-building tool will slide off the plug. Make sure that the directional drilling hand knows how to tally pipe correctly. That is his job, but I have seen experts make a 30-ft mistake. Before he drills, check his figures and make sure you both come up with the same number. If a mistake is made, another plug will have to be set, and so it will be another 48 hours before anything can be done. Directional drillers make mistakes all the time. You have to choose them carefully. Make sure they have drilled several successful wells.

The hole to be logged can be drilled with water or field brine. Be prepared to fight a kick because you could drill into a pressurized zone while drilling vertical. This does not happen often, but a smart consultant will have the crews trained and ready to work the PWD equipment at this point.

Also you can drill the vertical hole with the cuttings going through the chokes and to the separation tanks. This also will teach the crews how to use the equipment before horizontal drilling is begun. A show of oil will probably appear.

Before you withdraw from the hole, shut down the pumps and check for a small flow. If a small flow occurs, you can add to the system a little heavier brine water. This can be done by slowly opening the brine tanks to the mud tanks and mixing a heavier-weight brine water. Always be careful when you are in the chalk. After you are in the casing, also check for flow. Keep the water flowing to fill the hole while pipe is pulled. Let the overflow go through the chokes, but kick out the pumps every 1,000 ft and check for flow.

## TEXT 3 What are industrial robots and how do they work?

Although they vary widely in shape, size and capability, industrial robots are made up of several basic components: the manipulator, the control and the power supply (Figs. 5, 6).

The manipulator is the mechanical device which actually performs the useful functions of the robot. It is a hydraulically, pneumatically or electrically driven jointed mechanism capable of up to seven independent, coordinated motions. Feedback devices on the manipulator's joints or actuators provide information regarding its motions and positions to the robot control. A gripping device or tool, designed for the specific tasks to be done by the robot, is mounted on the outermost joint of the manipulator. Its function is directed by the robot's control system.

The control stores the desired motions of the robot and their sequence in its memory; directs the manipulator through this sequence or "program" upon command; and interacts with the machines, conveyors and tools with which the robot works. Controls range in complexity from simple stepping switches to minicomputers.

Hydraulically actuated robots also include an electrically driven lump, control valves, reservoir and heat exchanger in a power supply unit which provides fluid flow and pressure to drive the manipulator. Cooling water is also required by some robots to maintain hydraulic fluid temperature or for control cabinet temperature regulation. Pneumatically driven robots are usually connected (through a filter-regulator) to the factory compressed air system.

Industrial robots exist in a wide range of capabilities and configurations. However, they commonly consist of several similar major components: the manipulator, the controller, and power supply. The most common manipulator configurations are related to the coordinate systems in which they function: cartesian, cylindrical, polar and revolute.

The drive system may be pneumatic, hydraulic or electromechanic. The controllers initiate the motion of the manipulator, actuate tools or grippers and transmit and receive signals to and from the other equipment with which the robot operates.

The function of the power supply is to provide energy to the manipulator's actuators. In the case of electrically driven robots, the basic function of the power supply is to regulate the incoming electrical energy. Power for pneumatically actuated robots is usually supplied by a remote compressor which may also service other equipment. Hydraulically actuated robots normally include a hydraulic power supply as either an integral part of the manipulator or as a separate unit.

Industrial robots are made of the following major (basic) components: the manipulator, the control and the power supply. The control is a device by which a person may communicate commands to a machine. The manipulator is a mechanism, usually consisting of a series of segments, jointed or sliding relative to one another for the purpose of grasping and moving objects usually in several degrees of freedom. It may be remotely controlled by computer or by a person. The power supply provides energy to the robot actuators to produce motion. A robot electric power supply unit provides only the DC (direct current) voltages required by the electronic circuits internal to the robot controller.

**TEXT 4 Are oil supplies now falling?**

Over the last 150 years, there has been a rapid increase in the amount of oil produced around the world. The result has been a rapid economic growth and a higher standard of living However, oil is a finite, non-renewable resource and many people believe that there will be a time when oil production (extraction and refining) from conventional wells begins to decline. This will happen when we have used up about half of the possible reserves.

Up until now oil companies have extracted oil from easy-to-reach places on land, near the surface, under pressure, light and sweet. Now oil extraction is taking place offshore, in deep wells, and in environmentally sensitive areas and in the future in will become increasingly expensive to extract oil in these more difficult environments. In December 2005, William J Cummings a spokesman for Exxon-Mobil company, said, 'All the easy oi and gas in the world has pretty much been found. Now comes the harder work in finding and producing oil from more difficult environments and work areas.'

M King Hubbert was a geophysicist who worked for Shell Oil Company. He developed a theory known as the Hubbert Peak Theory which says that production of oil reaches a maximum point, or peak, and then begins to decline. He showed this in a bell-shaped curve. In 1956 he predicted that US oil production would peak sometime in the late 1960s or early 1970s and that world oil would peak sometime between 1995 and 2000. US oil production peaked in 1970/71.

Deciding on a time when world oil production will peak is very difficult. Most people agree that oil production will peak but they can't agree when this will happen. Production from many of the world's largest oilfields is now in decline and some people believe that oil production peaked up to ten years ago. However, new oilfields are beginning production and many people believe that the peak hasn't been reached yet. We will only know when production has peaked after it has happened!

People also disagree about the results of peak oil. Some believe that as oil supplies fall, prices will rise because supply won't meet demand and we will have to change the way we live dramatically. They say that products produced from oil will become scarce. Other people believe that developments in technology will mean that life will change very little. It is already possible to extract a higher percentage of oil from conventional wells. Oil can also be extracted from unconventional sources, for example heavy crude oil, oil sands, and oil shale, but production costs are high. Some people believe that new technology in transport and more efficient use of power will mean that the demand for oil will fall and that there will be enough oil to meet demand for many years in the future. If we control oil production carefully, there will be enough oil for the next hundred years.

**TEXT 5 A waste of resources**

People throughout the world need energy but every year billions of dollars' worth of natural gas are wasted. Natural gas is flared on oil production rigs, in refineries, and in chemical plants across the world. Flaring is the burning of natural gas which is not required or a way of reducing pressure at oil and gas facilities. People now realize that it is a waste of energy, resources, and money.

Pressure release valves release gas when the pressure in plant equipment is too high. This is a safety device to protect vessels and pipes. The released gases are burned as they leave the flare stack. When a large amount of gas is released, the flame burns very brightly. Even when pressure is normal, a small amount of gas is constantly burned so the system is ready.

In some countries, for example Nigeria, large amounts of natural gas are trapped with the oil as it is extracted. This is known as associated gas. Because there was little demand for natural gas in the country in the past the large quantities of associated gas were burned off. Oil companies are now working to reduce this.

Flaring and venting of natural gas from oil and gas wells is responsible for large quantities of greenhouse gases which are responsible for global warming. Experts estimate that over 150 billion cubic metres of natural gas are flared each year. This is about 25 per cent of the United States' gas consumption or 75 per cent of Russia's gas exports. Russia is responsible for the highest levels of flaring, followed by Nigeria, Iran, and Iraq. Information about the amount of gas flaring has been collected from satellite data.

Major oil companies and governments are now working together to reduce flaring and to recover and use this associated natural gas. The Global Gas Flaring Reduction Public-Private Partnership (GGFR) was set up in 2002. Its aim is to support governments, agencies, and the petroleum industry to reduce flaring and venting of gas. GGFR offers advice to governments and oil companies and also helps develop markets for the associated gas. Associated gas is now being used to supply domestic customers, and to produce electricity and liquefied natural gas (LNG).

## 2.4 Глоссарий, мини-словарь узкоспециализированных терминов

**A**

abandonment ликвидация скважины
absolute permeability абсолютная проницаемость
acidizing кислотная обработка
acoustic log акустический каротаж
additive manufacturing аддитивное производство
advanced composites композитные материалы нового поколения
alarm сигнализация / тревога
analytical foundation аналитическая основа
anomaly detection обнаружение аномалий
annulus затрубное пространство
anticline антиклиналь
API gravity плотность API
appraisal well оценочная скважина

aquifer водоносный горизонт
artificial intelligence (AI) искусственный интеллект
artificial lift механизированная добыча
asphaltene асфальтен
autonomous автономный

**B**
barrel (bbl) баррель
base oil базовое масло
bbl/day баррелей в сутки
BHP (bottomhole pressure) забойное давление
BHT (bottomhole temperature) забойная температура
bit долото
bitumen битум
bleed off стравливать (давление)
blowout открытый фонтан
blowout preventer (BOP) противовыбросовое оборудование
borehole stability устойчивость ствола скважины
bottomhole assembly (BHA) компоновка низа бурильной колонны
break-even price цена безубыточности
breakthrough прорыв (агента, воды, газа)
brine пластовая вода / рассол
bullheading задавка в пласт
bundle carrier трубка-спутник

**C**
C1 (methane) метан
C2 (ethane) этан
C3 (propane) пропан
capability beyond petroleum компетенции за пределами нефтегаза
capillary pressure капиллярное давление
CAPEX (capital expenditure) капитальные затраты
carbonate reservoir карбонатный коллектор
casing обсадная колонна
casing shoe башмак обсадной колонны
catalyst катализатор
catalytic cracking каталитический крекинг
catwalk мостки для труб
cement slurry цементный раствор
cementing цементирование
centrifugal pump центробежный насос

challenging reservoir conditions сложные коллекторские условия
check for leaks проверять на утечки
choke штуцер / дроссель
circulate циркулировать
clay swelling набухание глин
cloud-based platform облачная платформа
coil tubing гибкая насосно-компрессорная труба
collar муфта
commercial plant промышленная установка
commodity price цена на сырьевой товар
compaction уплотнение
completion заканчивание скважины
condensate конденсат
confined space замкнутое пространство
coning конусообразование
contingency plan план действий в аварийных ситуациях
continuous improvement постоянное улучшение
control контролировать, регулировать
conversion конверсия / глубина переработки
core sample керн
corrosion коррозия
corrosion inhibitor ингибитор коррозии
corrosive коррозионный / едкий
creaming расслаивание эмульсии
crude oil сырая нефть
cuttings шлам

**D**
dashboard панель управления (дашборд)
data acquisition сбор данных
data integration интеграция данных
data-driven основанный на данных
dead oil дегазированная нефть
decarbonization декарбонизация
decommissioning вывод из эксплуатации
dehydration обезвоживание
deliverability производительность скважины
demulsifier деэмульгатор
depletion истощение
desalter обессоливающая установка
desanding удаление песка

development well эксплуатационная скважина
deviation survey инклинометрия
dew point точка росы
dexterous manipulation манипулирование с высокой точностью
differential pressure перепад давления
diffusion диффузия
digital oilfield цифровое месторождение
digital twin цифровой двойник
directional drilling наклонно-направленное бурение
discount rate ставка дисконтирования
displacement efficiency коэффициент вытеснения
displace вытеснять, продавливать
dissolved gas растворённый газ
distillation перегонка / дистилляция
domestic внутренний (отечественный)
doublet нагнетательная + добывающая скважины
downhole забойный
downstream нижний сегмент (переработка и сбыт)
downtime простой
drill out разбуривать
drill pipe бурильная труба
drill string бурильная колонна
drilling бурение
drilling fluid буровой раствор
drilling rig буровая установка
drone беспилотный летательный аппарат
dry gas сухой газ
dynamic modeling динамическое моделирование

**E**

eccentricity эксцентриситет
economic limit экономический предел
edge computing периферийные вычисления
EIA (environmental impact assessment) оценка воздействия на окружающую среду
electrical submersible pump (ESP) электроцентробежный насос (ЭЦН)
emergency shutdown (ESD) аварийное отключение
emergency response реагирование на аварийные ситуации
emergency response plan план реагирования на аварии
emissions reduction сокращение выбросов

employment занятость
emulsion эмульсия
energy security энергетическая безопасность
energy transition энергетический переход
enhanced oil recovery (EOR) увеличение нефтеотдачи (МУН)
entry point точка входа
environmental compliance соблюдение природоохранных требований
EOR screening скрининг методов МУН
equivalent circulating density (ECD) эквивалентная циркуляционная плотность
evacuation эвакуация
exploration разведка
exploration well поисковая скважина
expandable casing расширяемая обсадная колонна

**F**
faciesфации
failure analysis анализ отказов
failure prediction прогнозирование отказов
fault разлом
feedstock сырьё
field development plan проект разработки месторождения
filtration фильтрация
finite difference метод конечных разностей
firefighting system система пожаротушения
flammable легковоспламеняющийся
flare факел
flow assurance обеспечение потока
flow line выкидная линия
flow rate дебит (расход)
fluid флюид
fluid catalytic cracking (FCC) каталитический крекинг в псевдоожиженном слое
fluidized bed псевдоожиженный слой
formation пласт
formation damage кольматация пласта
formation pressure пластовое давление
formation water пластовая вода
fracturing fluid жидкость разрыва
fracture gradient градиент разрыва (пласта)
free water knockout (FWKO) водоотделитель

fuel gas топливный газ
full bore полнопроходной

**G**
gas chromatograph газовый хроматограф
gas condensate газоконденсат
gas detector газоанализатор
gas injection закачка газа
gas lift газлифт
gas processing plant (GPP) газоперерабатывающий завод (ГПЗ)
gas to oil ratio (GOR) газовый фактор
gasification газификация
gathering center сборный пункт
geological exploration геологическая разведка
geological model геологическая модель
geophone геофон
geothermal gradient геотермический градиент
geotechnical model геотехническая модель
global demand мировой спрос
GOR (gas/oil ratio) газовый фактор
governing equation определяющее уравнение
gravel pack гравийная набивка
greenfield новое месторождение
gross domestic product (GDP) валовой внутренний продукт
gross pay общая толщина пласта

**H**
$H_2$ S (hydrogen sulfide) сероводород
hard hat каска защитная
harsh environment агрессивная среда
hazard опасность / вредный фактор
hazard identification (HAZID) идентификация опасностей
hazardous area опасная зона
HAZOP анализ опасностей и эксплуатационной пригодности
head (pump) напор
hearing protection защита слуха
heater treater печь-сепаратор (подогреватель)
heavy oil тяжёлая нефть
hedging хеджирование / осторожная формулировка
heterogeneity неоднородность
high risk высокий риск

historical data исторические данные
hold (pressure) держать (давление)
horizontal well горизонтальная скважина
HPHT высокое давление высокая температура
HSE охрана труда, техника безопасности, экология
human error человеческая ошибка
hurdle rate барьерная ставка
hydrate гидрат
hydrate inhibitor ингибитор гидратообразования
hydraulic fracturing гидравлический разрыв пласта (ГРП)
hydrocarbon углеводород
hydrocyclone гидроциклон
hydrogen production производство водорода
hydrotreating гидроочистка

**I**
immiscible несмешивающийся
imported crude импортная сырая нефть
incident инцидент / происшествие
incident reporting регистрация инцидентов
injectivity приёмистость
injector well нагнетательная скважина
inspection инспекция / обследование
integrity целостность
interfacial tension (IFT) межфазное натяжение
internal rate of return (IRR) внутренняя норма доходности
interoperability совместимость систем
Internet of Things (IoT) интернет вещей
irreducible water saturation остаточная водонасыщенность

**J**
jar (tool) ясс
jet pump струйный насос

**K**
kick газонефтепроявление
kill fluid жидкость глушения
kelly ведущая труба

**L**
laboratory experiment лабораторный эксперимент

LACT unit автоматический узел учёта нефти
lag time отставание
land-based наземный (сухопутный)
laser descaling лазерное удаление окалины
latency задержка (латентность)
leak detection обнаружение утечки
LEL нижний концентрационный предел воспламенения
light ends легкие фракции
liquefied natural gas (LNG) сжиженный природный газ
lithology литология
lock-out / tag-out (LOTO) отключение и маркировка оборудования
log каротаж
logging while drilling (LWD) каротаж в процессе бурения
lost circulation поглощение бурового раствора
low permeability низкая проницаемость
low risk низкий риск
lower опускать
lump sum единовременные затраты

**M**

machine learning (ML) машинное обучение
macroscale макромасштаб
magnetic field магнитное поле
maintenance техническое обслуживание
major accident крупная авария
manifold гребёнка / манифольд
MAOP максимальное разрешённое рабочее давление
marginal project низкорентабельный проект
market volatility волатильность рынка
matrix матрица (породы)
measurement while drilling (MWD) измерения в процессе бурения
methanol метанол
MEG (monoethylene glycol) моноэтиленгликоль
midstream средний сегмент (транспорт и хранение)
miscible смешивающийся
model training обучение модели
mud буровой раствор
mud logging шламовый каротаж
mud weight плотность бурового раствора
multilateral well многозабойная скважина
multiphase flow многофазный поток

muster point пункт сбора

**N**

near miss предпосылка к инциденту *NEW
net pay эффективная толщина
net present value (NPV) чистая приведённая стоимость
net-to-gross коэффициент песчанистости
nitrogen азот
nondestructive testing неразрушающий контроль
non-damaging fluid раствор, не повреждающий пласт
non-Newtonian fluid неньютоновская жидкость
numerical simulation численное моделирование

**O**

OBM (oil-based mud) раствор на углеводородной основе
octane октановое число
offshore морской шельф
oilfield services нефтепромысловые услуги
oil in place (OIP) геологические запасы нефти
oil recovery извлечение нефти
oil recovery factor коэффициент извлечения нефти
oilfield нефтяное месторождение
on-demand по требованию
onboard electronics бортовые электронные системы
OOIP (original oil in place) начальные геологические запасы
OPEX (operating expenditure) операционные затраты

**P**

packer пакер
paraffin парафин
payback period срок окупаемости
payload полезная нагрузка
perforation перфорация
permeability проницаемость
permit-to-work (PTW) наряд-допуск
personal protective equipment (PPE) средства индивидуальной защиты (СИЗ)
petroleum sector нефтяной сектор
petroleum system нефтегазовая система
pig скребок / поршень-разделитель
pigging очистка трубопровода скребком

pilot test	пилотный проект
pioneering work	пионерская работа
pipeline	трубопровод
plasticity	пластичность
polymer flooding	полимерное заводнение
porous medium	пористая среда
porosity	пористость
ppg (pounds per gallon)	фунтов на галлон
ppm (parts per million)	частей на миллион
predictive maintenance	предиктивное обслуживание
pressure drawdown	депрессия (на пласт)
pressure transient analysis	гидродинамические исследования
pressure up	создавать давление, опрессовывать
primary recovery	первичная добыча
produced water	пластовая вода (попутно добываемая)
production	добыча
production casing	эксплуатационная колонна
production log	расходометрия
production sharing agreement (PSA)	соглашение о разделе продукции
progressive cavity pump (PCP)	винтовой насос
project execution	реализация проекта
proppant	проппант
proven reserves	доказанные запасы
PSI	фунт на квадратный дюйм
pull out	извлекать (поднимать)
pump	насос
PVT	PVT (фазовое поведение)

**Q**

quality assurance	обеспечение качества

**R**

radioactivity log	радиоактивный каротаж
raise	поднимать, увеличивать
real-time data	данные в реальном времени
real-time monitoring	мониторинг в реальном времени
recovery	извлечение
reforming	риформинг
refinery	нефтеперерабатывающий завод (НПЗ)
refining	переработка нефти
regulatory authority	регулирующий орган

relative permeability относительная проницаемость
relief system система сброса давления
remote operation дистанционное управление
repurposing infrastructure перепрофилирование инфраструктуры
reservoir коллектор / резервуар
reservoir engineering разработка месторождений
reservoir simulation гидродинамическое моделирование
resistivity log каротаж сопротивлений
response time время реагирования
respirator респиратор
rheology реология
risk риск
risk assessment оценка рисков
risk management управление рисками
risk matrix матрица рисков
riser райзер (колонна)
robotic crawler роботизированное гусеничное устройство
robotic pig роботизированный скребок
rod pump штанговый насос
rotate вращать
rotary table ротор
roughness шероховатость
run (tubing run) спуск
run pipe back спускать трубы обратно

**S**
safety безопасность
safety case обоснование безопасности
safety data sheet (SDS) паспорт безопасности материала
safety glasses защитные очки
salinity солёность
sand control борьба с выносом песка
sand production вынос песка
saturation насыщенность
SCADA система диспетчерского управления и сбора данных
scale отложение солей
scientific breakthrough научный прорыв
screening criteria критерии отбора
seawater морская вода
secondary recovery вторичная добыча
sediment осадок

seismic сейсмика
sensor датчик / сенсор
sensor network сеть датчиков
separator сепаратор
set (tool) устанавливать (инструмент)
shale глина / сланец
shale gas сланцевый газ
shear thinning псевдопластичность
shut-in остановка (скважины)
single-phase flow однофазный поток
skill transfer передача навыков
slickline стальной трос (проволока)
slug оторочка (жидкости)
smart pig интеллектуальный скребок
smart well интеллектуальная скважина
sour gas кислый газ (с $H_2S$)
sovereign wealth fund суверенный фонд благосостояния
SPE (Society of Petroleum Engineers) Общество инженеров нефтяников
specific gravity удельный вес
spot (cement) устанавливать (цемент) в заданном месте
squeeze (job) цементирование под давлением (скважины)
state-owned государственный
steel-toed boots ботинки с защитным подноском
stimulation интенсификация
subsurface недра
sucker rod насосная штанга
superficial velocity приведённая скорость
support поддерживать
surfactant поверхностно-активное вещество
surge analysis анализ гидравлических ударов
sustainable устойчивый
sweep efficiency коэффициент охвата
sweet gas сладкий газ (без $H_2S$)
synthetic oil синтетическое масло

**T**
tag (cement) доходить до (цементной) пробки, фиксировать глубину
tank battery резервуарный парк
tank inspection обследование резервуара
TD (total depth) конечная глубина
template шаблон / платформа

tertiary recovery третичная добыча
test испытывать, проверять
thermal cracking термический крекинг
thermal EOR тепловые методы МУН
three-phase separator трёхфазный сепаратор
throttle дроссель
tight oil трудноизвлекаемая нефть
tool face orientation ориентирование отклонителя
torque крутящий момент
total dissolved solids (TDS) общее содержание солей
toxic токсичный
tracer индикатор
training dataset обучающая выборка данных
transferrable skills передаваемые навыки
transition переход (энергетический)
trip out / in поднимать / спускать инструмент
tubing насосно-компрессорные трубы (НКТ)

**U**
underbalance депрессия (на пласт)
unsteady state неустановившийся режим
upstream верхний сегмент (разведка и добыча)
upscaling масштабирование (укрупнение сетки)

**V**
vapor recovery улавливание паров
vertical lift performance (VLP) характеристика подъёмника
vertically integrated company вертикально интегрированная компания
viscosity вязкость
viscosifier загуститель
visualization визуализация
volumetric method объёмный метод

**W**
water breakthrough прорыв воды
water coning водяной конус
water cut обводнённость
water flooding заводнение
water shut-off водоизоляция
wax appearance temperature (WAT) температура выпадения парафина

wax deposition отложение парафина
weak point слабое место
well construction строительство скважины
well control контроль скважины
well intervention вмешательство в скважину
well logging каротаж
well testing исследование скважин
wellbore ствол скважины
wellhead устьевое оборудование
wet gas влажный газ
wireline кабельный транспорт
without hydraulic supply lines без гидравлических линий подачи
workforce рабочая сила
workover капитальный ремонт скважины

**Y**

yield stress предел текучести
yield value статическое напряжение сдвига

**Z**

zero offset нулевое смещение
zeta potential дзета-потенциал
zonal isolation зональная изоляция
zone зона / интервал