

石油工程系：油气田开发工程教研室

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Introduction to Petroleum Industry

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petrophysics

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Petrophysics Syllabus

Major petroleum engineering

Period 54 Credit Hour 3

Course Type general classes for specific major

Course Character a required course

A Course Objective

This course is a general class for petroleum engineering students, and it has a strong property to practice students' ability which is especially important for this major. This course intends to introduce the physical properties of reservoir rock, the physical properties of reservoir fluid and the character of fluid flowing through porous media. It is the basic of the fluid flowing through porous media, reservoir engineering as well as enhanced oil recovery.

B. Topics

Introduction

- 1 Study object and content of petrophysics
- 2 The import of petrophysics
- 3 Development of petrophysics
- 4 The class characteristic and study policy
- 5 The relationship between petrophysics and other classes
- 6 References

Chapter1 The physical property of reservoir rock

1.1 The property of reservoir rock

1.1.1 Sand size and sand size distribution

1.1.2 The specific surface of reservoir rock

1.1.3 Cement and cementation character

1.2 The porosity of reservoir rock

1.2.1 The pore structure

1.2.2 Porosity

1.2.3 Factors affecting porosity

1.2.4 The measurement method of porosity

1.2.5 Compressibility of reservoir rock

1.3 The permeability of reservoir rock

1.3.1 Darcy's law

1.3.2 The definition and physical meaning of permeability

1.3.3 The measurement method of permeability

1.3.4 Factors affecting permeability

1.3.5 The relationship between permeability, porosity, specific surface and pore radius

- 1.4 Saturation
 - 1.4.1 Basic concept of saturation
 - 1.4.2 Main saturation
 - 1.4.3 Factors affecting saturation
 - 1.4.4 The measurement method of saturation
- 1.5 The sensitivity and sensitivity evaluation of reservoir rock
 - 1.5.1 The sensitivity and sensitive mineral
 - 1.5.2 The evaluation method of sensitivity
- 1.6 Other physical properties of reservoir rock
 - 1.6.1 Mechanics properties of reservoir rock
 - 1.6.2 Thermal properties of reservoir rock
 - 1.6.3 Conductivity of reservoir rock
 - 1.6.4 Radioactivity of reservoir rock
 - 1.6.5 Magnetic Properties of reservoir rock
- 1.7 Average calculation method of rock parameters
 - 1.7.1 Aarithmetic average
 - 1.7.2 Weighted average
 - 1.7.3 Physical average

focus

porosity, permeability, saturation and sensitivity

difficulty

how to combine with physical properties of various rocks and reservoir development process

Chapter2 Physical properties of reservoir fluid

- 2.1 Physical properties of nature gas at high pressure
 - 2.1.1 Basic concept of nature gas
 - 2.1.2 Phase state equation of nature gas
 - 2.1.3 Physical properties of nature gas at high pressure
- 2.2 Physical properties of reservoir oil at high pressure
 - 2.2.1 Basic concept of oil
 - 2.2.2 Oil-gas ratio
 - 2.2.3 Physical properties of reservoir oil at high pressure
- 2.3 Physical properties of formation water at high pressure
 - 2.3.1 Basic concept of formation water
 - 2.3.2 Classification of formation water
 - 2.3.3 Physical properties of formation water at high pressure
 - 2.3.4 Water standard and the method of processing water
- 2.4 Phase state characteristic of hydrocarbon in the reservoir
 - 2.4.1 Phase state characteristic of hydrocarbon in the reservoir

2.4.2 Phase state diagram and application

2.4.3 Several typical phase state diagrams

2.5 Phase state equation

2.5.1 Dissolution and separation of oil and nature gas

2.5.2 Phase state equation

2.5.3 Application of phase state

focus

physical parameter on oil, nature gas and formation water, phase state transformation of reservoir fluid

difficulty

how to calculate these parameters

Chapter3 Percolation characteristic of multiphase fluid flowing through porous media

3.1 Interface phenomena of reservoir fluids

3.1.1 Free surface energy and interface phenomena

3.1.2 Interfacial tension

3.1.3 Adsorption phenomena

3.2 Wettability of reservoir rock

3.2.1 The wettability of rock

3.2.2 Essential of wetting

3.2.3 Wettability hysteresis

3.2.4 The wettability of reservoir rock and the distribution of oil and water in the porous media

3.2.5 The measurement method of wettability

3.3 Capillary phenomena and capillary pressure curve in the reservoir

3.3.1 Capillary phenomena in the reservoir

3.3.2 A variety of resistance phenomena in the reservoir

3.3.3 Capillary pressure curve

3.3.4 The measurement method of capillary pressure curve

3.3.5 Application of capillary pressure curve

3.4 Relative permeability and relative permeability curve

3.4.1 Several important concept (absolute permeability, effective permeability, relative permeability, mobility, mobility ratio and water cut)

3.4.2 Relative permeability curve and application

3.4.3 The measurement method of relative permeability curve

3.5 Microscopic mechanism on fluid flowing through porous media

3.5.1 Percolation phenomena of several simplified model

3.5.2 Microscopic mechanism on fluid flowing through porous media

focus

all kinds of interface phenomena, capillary pressure curve and relative permeability curve
difficulty

how to analyze all kinds of interface phenomena and physical process during oil field development or gas field development?

Chapter 4 The principle of enhanced oil recovery

4.1 Basic approach of EOR

4.1.1 What is oil recovery?

4.1.2 Factors affecting EOR

4.1.3 Basic approach of EOR

4.2 Mechanism of three EOR methods

4.2.1 Mechanism and applicability on thermal flooding

4.2.2 Mechanism and applicability on chemical flooding

4.2.3 Mechanism and applicability on miscible flooding

4.3 Feasibility analysis and evaluation on three EOR methods

4.3.1 Development trend on three EOR methods

4.3.2 Feasibility analysis on three EOR methods

4.3.3 Evaluation on three EOR methods

focus

factors affecting EOR, basic approach of EOR and mechanism of three EOR methods

difficulty

how to bring forward the approach of EOR and how to come true?

C. What will you learn?

1 Students should learn the following knowledge through this course:

- (1) Understand basic characteristics of reservoir rock
- (2) Understand basic physical properties of reservoir fluid
- (3) Understand basic rule of fluid flowing through porous media
- (4) Understand basic principle of EOR

2 Students need to understand the fundamental concepts and apply them in the oil field or gas field development.

3 Students need to understand the principles to measurements, experimental methods on all kinds of parameters and bring up the ability to do experiment.

D. Class timetable

Topic	Period Hours
1 Introduction	2
2 The physical property of reservoir rock	16
3 The physical property of reservoir fluid	10
4 Percolation characteristic of multiphase fluid flowing through	16

porous media	
5 The principle of enhanced oil recovery	10
Total	54

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Gas Production Engineering

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Percolation Flow Through Porous Media Mechanics

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The Principle Of Enhanced Oil Recovery

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Foundation of Oilfield Development Geology

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Oil & gas Production DataBase and Its Application

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Case Study of Production Engineering

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Offshore Oil and Gas Production Technology

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Reservoir Numerical Simulation

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Oil & Gas Reservoir Performances Monitoring

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Introduction to Petroleum Engineering

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Teaching program for Drilling Engineering (Bilingual Teaching)

Course Drilling Engineering (Bilingual Teaching)

Speciality Petroleum Engineering

periods 64 credits 3.5

classification Fundamentals of subject curriculum

property Required

I Course Property & Teaching Objective

This is the one of the backbone course for petroleum engineering specialty, also it's the required course for petroleum engineering students. It aims at letting students understand the major drilling technologies and the involved operation programs, drilling equipment, all the conventional downhole drill tools, technical principle, theoretical methods, engineering calculation method, and its field application, and also the drilling engineering technology development tendency, emerging drilling technique and technology, and the frontier research on drilling engineering.

II Course Contents

Introduction

Basic contents and requirement

Drilling engineering development

Rig composition

Major drilling technology and the involved operation programs

Chapter 1 Well Drilling Geological Conditions

Basic contents and requirement

Section 1 Formation Stresses & Downhole Pressures

Formation pore pressure evaluation and formation stresses

Fracturing press

Section 2 Rocks Engineering Characteristics

Rock mechanic properties

Rock mechanic properties in subsurface and the related influence factors

Rock abrasiveness

Rock drillability

Rock hardness and plasticity

Teaching emphasis

1 Pore pressure, fracturing pressure and their prediction

2 Basic influencing factors in rock strength

3 Rock hardness, plasticity and their influence on drilling

Chapter 2 Drilling Tools: Bit & Drill Stem

Basic contents and requirement

Section 1 Bit

Drag bit structure and its operation mechanism

Cone bit structure and its operation mechanism

Diamond bit structure and its operation mechanism

Bit type and its classification

Section 2 Drill Stem

Drill string function and its composition

Drill string running state and its mechanic analysis

Teaching emphasis

- 1 Cone and PDC bit rock crushing mechanism and its application
- 2 Drill stem composition and its mechanic analysis in different conditions
- 3 Drill tool fatigue and its prevention

Teaching nodus

Drill stem mechanic analysis in practical downhole conditions

Chapter 3 Drilling Fluids

Basic contents and requirement

Section 1 Introduction: Definition & Function

Definition

Functions

Section 2 Composition & Classification

Composition

Classification

Section 3 Drilling Fluids Properties

Density

Rheological property and its adjustment

Drilling fluids wall building property and fluid loss control additive

Section 4 Drilling Fluids Solid Control

Solid phase and its affection on ROP

Solid control method

Solid control equipment

Polymer flocculant

Section 5 Hole Sloughing & Its Prevention Measurements

Sloughing premonition and its danger

Measurements for hole sloughing

Section 6 Reservoir Damage Prevention & Well Completion Fluids

Major factor on formation damage and its prevention measures

Well completion fluids

Teaching emphasis

- 1 Drilling fluids composition and its systems
- 2 Drilling fluids properties and its adjustments
- 3 Solid control and its methods
- 4 Drilling fluids properties adjustment in mud and shale drilling
- 5 Well completion fluids properties requirements

Chapter 4 Drilling Parameters' Optimization

Basic contents and requirement

Section 1 Drilling Parameters their mutual effects

Major factors affecting ROP

ROP equation

Bit wear equation

Coefficients determination in ROP equation

Section 2 Drilling Parameters Optimizing in Rock Breaking

Target function establishing

Target function extreme value conditions and control conditions

Bit optimized wear rate , optimized WOB and optimized ROP

Section 3 Optimum Hydraulic Parameters Programming

Jet bit hydraulic characteristics

Basic hydraulic power transitive relations

Pressure loss in circulation system

Mud pump operating characteristics

Criteria for hydraulic parameters optimization

Maximum bit hydraulic power

Maximum jet impact force

Optimized hydraulic parameters design

Teaching emphasis

- 1 Influencing factors on ROP
- 2 Optimization method of drilling parameters
- 3 Calculation methods of hydraulic parameters
- 4 Optimization method of hydraulic parameters
- 5 Dealing method in engineering application

Teaching nodus

Hydraulic parameters change as well deepening in field application

Chapter 5 Well control

Basic contents and requirement

Section 1 Down hole Pressures & Their Relationship

Relationship between wellbore and formation

Balanced drilling

Underbalanced drilling

Section 2 Formation Fluids Intrusion & Checking

Formation fluids invasion in wellbore

Gas/liquid flow pattern distribution and flow characteristics in annulus while gas invasion

Detection of formation fluids invasion

Section 3 Formation Fluids Intrusion Control

Well shutting in program while Well kick

Heavy mud density determination in Kill well

Kill well theory and method

Teaching emphasis

- 1 Near-balanced, underbalanced drilling method
- 2 Premonition of formation fluids invasion
- 3 Gas invasion characteristics
- 4 BOP
- 5 Kill well calculation and methods

Teaching nodus

Kill well operation calculation and requirements in hole bottom pressure balance condition

Chapter 6 Directional Well Profile Design & Well Track Control

Basic contents and requirement

Section 1 Basic Concepts of well track

Wellbore trajectory parameters

Wellbore calculation

Wellbore schematic denotation

Section 2 Well Profile Measuring & Its Calculation

Wellbore survey method and inclinometer

Survey data

Trajectory profile calculation methods

Section 3 Vertical Hole Drilling Techniques for Deviation Prevention

Hole deviation factors analysis

Packed BHA in hole deviation control

Pendulum BHA in hole deviation control

Section 4 Directional Well Profile Design

Classification of directional well profile

Conventional 2D directional well profile design

Section 5 Kick Off Tools & Its Track Control

Deflecting tools in rotary table drilling

Deflection tools in downhole PDM drilling

Directional drilling trajectory control

Azimuth correction calculation

Deflecting tool application

Section 6 Introduction to Horizontal Well Drilling

Horizontal well introduction

Horizontal well economic benefit and application foreground

Horizontal drilling key point

Teaching emphasis

1 Directional well profile design and calculation

2 Deviation control in vertical drilling

3 Directional drilling tools

4 Directional trajectory control

5 Horizontal well drilling characteristics

Teaching nodus

Well trajectory control mechanism and methods

Chapter 7 Casing & Cementing, and Well Completion Methods

Basic contents and requirement

Section 1 Well Schematic Design

Casing types

Wellbore configuration principle

Design coefficients

Wellbore configuration design method

Casing sizes & hole sizes selection

Section 2 Casing String Design

Casings & casing strings

Casing string mechanical analysis and string strength

Casing strength design principle

Section 3 Cementing Technology

Cement

Cement property and its effect on cementing engineering

Prepad fluid system

Measures for improving cementing quality

Section 4 Well Completion

Open the reservoir

Well completion principle and the completion borehole bottom structure types

Open hole completion

Perforation completion

Sand exclusion completion

Special completion method

Well head elements

Teaching emphasis

- 1 Well bore configuration Design coefficients
- 2 Casing strength design for complicated stresses consideration
- 3 Factors analysis for displacement efficiency
- 4 Completion method and its adaptability

Teaching nodus

Design coefficients determination, casing strength design and the involved theory

Chapter 8 Downhole Troublesome Conditions & Its Treatment

Basic contents and requirement

Well Control Failure & Its Treatment

Lost Circulation while Drilling

Stuck Pipe Treatment

Drill String Failure & Its Treatment

Downhole Junk Treatment

Teaching emphasis

- 1 Lost circulation types
- 2 Pipe sticking point determination
- 3 Method for downhole drill pipe problems treatment

Teaching nodus

Pipe sticking point determination

Chapter 9 Unusual Drilling Technology

Basic contents and requirement

Section 1 Coring Technology

Introduction

Coring tools

Measures for improving core sample recovery efficiency

Section 2 Casing Exiting Technology

Whipstocks for casing exiting

Enlarging mill shoe for casing exiting

Section 3 Drilling with Casing

Section 4 Coiled Tubing Drilling Technology

Teaching emphasis

- 1 Core types and coring technology
- 2 Casing exiting technology and its application
- 3 Drilling with casing characteristics

Teaching nodus

Advanced coring technology and its development

3. Course Teaching Requirements

1 This course involves classroom teaching, experiments, students self-study, exercises discussion, exercises, question answering, and examination, etc.

2 Adopting large information multimedia teaching integrated theory with production practice, adopting elicitation method in classroom teaching, citing engineering examples, leading students to understand theory and its engineering application, increasing students study interest and enthusiasm.

3 Demanding and inducing students read other text books & treatise, consulting speciality articles, encouraging students study technology in world big petroleum service companies web. Reading and understanding text books contents, learning to knowledge self-study, fostering students knowledge capture ability.

4 Through this course teaching, let students grasp knowledge and can apply knowledge in solving engineering problems, possessing engineering quality.

IV Periods Assignment

Contents	Periods
Uction	2
Chapter 1 Well Drilling Geological Conditions	6
Chapter 2 Drilling Tools: Bit & Drill Stem	6
Chapter 3 Drilling Fluids	4
Chapter 4 Drilling Parameters' Optimization	6
Chapter 5 Well control	6
Chapter6 Directional Well Profile Design & Well Track Control	8
Chapter7 Casing & Cementing and Well Completion Methods	6
Chapter8 Downhole Troublesome Conditions & Its Treatment	4
Chapter 9 Unusual Drilling Technology	6
Total	54

V Supposed text book and reference

Text book

[1] Drilling Engineering, united writing by 4 universities (Daqing, Xi'an, ChangJiang, ChongQing), Petroleum Press, china, 2010

[2] Applied Drilling Engineering Adam T. Bourgoyne, etl.

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Writer NieCuiPing

Examiner LiQi

Reviser GuoJianMing

Ratifier JiangHuaYi

Separation Engineering

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Petroleum Engineering English

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Part A Petroleum Engineering Fundamentals

- 1-1 Petroleum
- 1-2 Geology of Petroleum
- 1-3 Exploration
- 1-4 Well Drilling & Completion
- 1-5 Production

Part B Advanced Technology in Petroleum Engineering

- 2-1 Directional Drilling
- 2-2 Horizontal, Multilateral, and Multibranch Wells in Petroleum Production Engineering
- 2-3 Multilateral Technology
- 2-4 MWD, LWD and Geosteering
- 2-5 Artificial-Lift Completions
- 2-6 Sand Stabilization and Exclusion
- 2-7 Conventional Well Stimulation
- 2-8 Water Control

Part C Extensive Reading Material in Petroleum Engineering

- 3-1 Drilling Fluids
- 3-2 Well Cementing
- 3-3 Underbalanced Drilling and Managed Pressure Drilling
- 3-4 Expandable Tubular Technology

- 3-5 Drilling with Casing (DWC)
- 3-6 Intelligent Well Completions
- 3-7 CT Technology
- 3-8 EOR Technology
- 3-9 Well Testing

Part B

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Part A Petroleum Engineering Fundamentals	
1-1 Petroleum	2
1-2 Geology of Petroleum	4
1-3 Exploration	4
1-4 Well Drilling & Completion	4
1-5 Production	4
Part B Advanced Technology in Petroleum Engineering	
2-1 Directional Drilling	4
2-2 Horizontal, Multilateral, and Multibranch Wells in Petroleum Production Engineering	4
2-3 Multilateral Technology	4
2-4 MWD, LWD and Geosteering	5

2-5 Artificial-Lift Completions	5
2-6 Sand Stabilization and Exclusion	5
2-7 Conventional Well Stimulation	5
2-8 Water Control	4
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Well Completion Engineering

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Fundamentals of Rock Mechanics

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Technology for the Prevention of Petroleum Formation from Damage

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Drilling Fluids Technology

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Case 1 Yinan - 2 Well Drilling Fluid Design 2
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Case 3 Mud Engineers Guide(Guide of Mud materials Usage)

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Petroleum Engineering English

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4

Part A Petroleum Engineering Fundamentals

1-1 Petroleum

1-2 Geology of Petroleum

1-3 Exploration

1-4 Well Drilling & Completion

1-5 Production

Part B Advanced Technology in Petroleum Engineering

2-1 Directional Drilling

2-2 Horizontal, Multilateral, and Multibranch Wells in Petroleum Production Engineering

2-3 Multilateral Technology

2-4 MWD, LWD and Geosteering

2-5 Artificial-Lift Completions

2-6 Sand Stabilization and Exclusion

2-7 Conventional Well Stimulation

2-8 Water Control

Part C Extensive Reading Material in Petroleum Engineering

3-1 Drilling Fluids

3-2 Well Cementing

3-3 Underbalanced Drilling and Managed Pressure Drilling

- 3-4 Expandable Tubular Technology
- 3-5 Drilling with Casing (DWC)
- 3-6 Intelligent Well Completions
- 3-7 CT Technology
- 3-8 EOR Technology
- 3-9 Well Testing

Part D Assigned English technical reports writing.

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Part A Petroleum Engineering Fundamentals	
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1-2 Geology of Petroleum	2
1-3 Exploration	3
1-4 Well Drilling & Completion	4
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2-5 Artificial-Lift Completions	4
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Part C Extensive Reading Material in Petroleum Engineering	
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3-5 Drilling with Casing (DWC)	3
3-6 Intelligent Well Completions	3
3-7 CT Technology	3
3-8 EOR Technology	3
3-9 Well Testing	2
Part D Assigned English technical reports writing. Geosteering, ESP/PCP, Horizontal well, IWC, etc.	4
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Engineering Fluid Mechanics II

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Pump and Compressor

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Corrosion and Anticorrosion

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Oil products in transportation and Storage Engineering

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Collection & Transportation for oil-gas

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Strength Design of the Oil Tank and Pipeline

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English in Oil & Gas Storage and Transportation

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Chapter 1 Oil and Gas Fields

- 1 An Introduction to Oil and Gas Production.
- 2 Brief Description of Crude Oil Surface Treatment.
- 3 Treating Oil Field Emulsions.
- 4 Overview of Gas-handling Facilities.
- 5 Trays and Packing
- 6 Gas Sweetening.
- 7 Dehydration of Natural Gas.
- 8 Hydrocarbon Recovery and Condensate Stabilization.

Chapter 2 Pipelines

- 1 Types of Pipelines.
- 2 Other Pipelines.
- 3 Rheology.
- 4 Line Pipes.
- 5 Pumps and Pump Stations.
- 6 Compressors.
- 7 Gas Turbines.
- 8 Pipeline Pigging.
- 9 Pipe Coating.
- 10 Inspection and Rehabilitation.

Chapter 3 Storage Facilities

- 1 Storage
2. Tank Classification
3. Floating-roof Tank.
4. Rim Seals.
5. Tank Emissions and Venting.
6. Tank Foundations.
7. Fire Prevention and Foam System.
8. Oil Storage in Rock Caverns

Chapter 4 Construction

- 1 Land Pipeline Construction.
- 2 Pipeline Installation and Road/River Crossing.
- 3 Offshore Pipeline Construction.
- 4 Pull Methods and Tie-in.
- 5 Welding Techniques and Equipment.

Chapter 5 Corrosion

- 1 Causes of Underground Corrosion.
- 2 Cathodic Protection Fundamentals.
- 3 Pipeline Corrosion.
- 4 Tank Corrosion.

Chapter 6 Metering Installations.

- 1 Metering Gases.
- 2 Metering of Liquids.
- 3 BTU Measurement.

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Design & Management for Oil Depot

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New Technology in Oil-Gas Storage & Transportation Engineering

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Measure Technique for Oil & Natural Gas

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Construction of Oil-Gas Storage & Transportation Facilities

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Fuel Gas Transmission and Distribution in City

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