COURSE OVERVIEW DE0813
Waterflooding Management
(E-Learning Module)

Course Title
Waterflooding Management
(E-Learning Module)

Course Reference
DE0813

Course Format & Compatibility
SCORM 1.2. Compatible with IE11, MS-Edge, Google Chrome, Windows, Linux, Unix, Android, IOS, iPadOS, macOS, iPhone, iPad & HarmonyOS (Huawei)

Course Duration
30 online contact hours
(3.0 CEUs/30 PDHs)

Course Description

This E-Learning course is designed to provide participants with a detailed and up-to-date overview of waterflooding management. It covers the water injection technology, waterflooding, waterflood configurations and field life cycle; the exploration, reservoir management approach, oil production processes, primary recovery, water injection system and thermal and non-EOR methods; the average recovery factors, types of data, factors common to all recovery methods and rock and fluid properties; the porosity, permeability and flow equation (Darcy law); and the effect of wettability, capillary pressure and reservoir fluid properties.

Further, the course will also discuss the reservoir hydrocarbon fluid classification, reserves estimation and classification and the method used for estimating dependent on data; the recovery and efficiency calculations, analogy method, ultimate recovery, decline curve analysis and reservoir simulation; the reservoir drive mechanisms and producing characteristics; the well & reservoir inflow performance, water drive expansion characteristics and gravity drainage in oil reservoirs; the oil recovery factors; the effects of gravity, attic gas injection, reservoir life cycle, infill drilling and main sources of injection water; and the crude oil dehydration, produced water management, typical water quality criteria and treatment of water for waterflooding.

Moreover, the course will also cover the pattern configurations, peripheral or repeating pattern flood, waterflood patterns, repeating pattern flood, basic flood pattern guidelines and optimum water flood pattern; the waterflood design procedure, waterflood patterns, empirical and analytical techniques, simulation technique and waterflood monitoring and management; the reservoir management process, waterflood monitoring and management, on-line monitoring, waterflood surveillance and pilot test design; and the injection and production profile modification, oil production processes, non-thermal methods and non-thermal oil recovery methods.

During this course, participants will learn the importance of mobility control, polymer flooding, properties of polymer solutions, stability and the effect of polymer retention; the guidelines for polymer application; the fluid characteristic, surfactant flooding method and the behavior of the anionic surfactant in the aqueous phase; the different structures of the micelle inside the aqueous solution and variation of conductivity with surfactant concentration; the field development optimization of waterflooding, EOR and well placement focusing on history matching and optimization algorithms; and the production optimization for waterflood and enhanced oil recovery.

Course Objectives

Upon the successful completion of this course, participants will be able to:-

- Apply and gain an in-depth knowledge on waterflooding management
- Discuss water injection technology, waterflooding, waterflood configurations and field life cycle
- Carryout exploration, reservoir management approach, oil production processes, primary recovery, water injection system and thermal and non-EOR methods
- Identify the average recovery factors, types of data, factors common to all recovery methods and rock and fluid properties
- Explain porosity, permeability, flow equation (Darcy law), the effect of wettability, capillary pressure and reservoir fluid properties
- Apply reservoir hydrocarbon fluid classification, reserves estimation and classification and the method used for estimating dependent on data
- Illustrate recovery and efficiency calculations, analogy method, ultimate recovery, decline curve analysis and reservoir simulation
- Recognize reservoir drive mechanisms and producing characteristics as well as well & reservoir inflow performance, water drive expansion characteristics and gravity drainage in oil reservoirs
- Estimate oil recovery factors and identify the effects of gravity, attic gas injection, reservoir life cycle, infill drilling and main sources of injection water
- Discuss crude oil dehydration, produced water management, typical water quality criteria and treatment of water for waterflooding
- Apply pattern configurations and describe peripheral or repeating pattern flood, waterflood patterns, repeating pattern flood, basic flood pattern guidelines and optimum water flood pattern

- Employ waterflood design procedure, analyzing waterflood patterns, empirical and analytical techniques, simulation technique and waterflood monitoring and management
- Illustrate reservoir management process, waterflood monitoring and management, on-line monitoring, waterflood surveillance and pilot test design
- Perform injection and production profile modification, oil production processes, non-thermal methods and non-thermal oil recovery methods
- Discuss the importance of mobility control, polymer flooding, properties of polymer solutions, stability and the effect of polymer retention
- Review the guidelines for polymer application and describe fluid characteristic, surfactant flooding method and the behavior of the anionic surfactant in the aqueous phase
- Explain the different structures of the micelle inside the aqueous solution and variation of conductivity with surfactant concentration
- Review field development optimization of waterflooding, EOR and well placement focusing on history matching and optimization algorithms
- Apply production optimization for waterflood and enhanced oil recovery

Who Should Attend

This course provides an overview of all significant aspects and considerations of waterflooding management for reservoir and production engineers, technical staff and geoscientists with interest in improved oil recovery by water flooding. Basic knowledge of reservoir engineering concepts is recommended. Further, the course is recommended for all engineers and technical staff (superintendents, supervisors & foremen) whose responsibilities include the safe and cost-effective operation of water injection systems. Management will also benefit by increasing their awareness of the cost-effective use of treatment chemicals and by developing their skills in analysis of water quality data. Furthermore, this course is suitable for corrosion personnel, W.I. personnel, lab personnel, chemists and chemical engineers.

Training Methodology

This Trainee-centered course includes the following training methodologies:-

- Talking presentation Slides (ppt with audio)
- Simulation & Animation
- Exercises
- Videos
- Case Studies
- Gamification (learning through games)
- Quizzes, Pre-test & Post-test

Every section/module of the course ends up with a Quiz which must be passed by the trainee in order to move to the next section/module. A Post-test at the end of the course must be passed in order to get the online accredited certificate.

Course Certificate(s)
Internationally recognized certificates will be issued to all participants of the course.

Certificate Accreditations
Certificates are accredited by the following international accreditation organizations: -

- USA International Association for Continuing Education and Training (IACET)

  Haward Technology is an Authorized Training Provider by the International Association for Continuing Education and Training (IACET), 2201 Cooperative Way, Suite 600, Herndon, VA 20171, USA. In obtaining this authority, Haward Technology has demonstrated that it complies with the **ANSI/IACET 1-2013 Standard** which is widely recognized as the standard of good practice internationally. As a result of our Authorized Provider membership status, Haward Technology is authorized to offer IACET CEUs for its programs that qualify under the **ANSI/IACET 1-2013 Standard**.

  Haward Technology's courses meet the professional certification and continuing education requirements for participants seeking **Continuing Education Units** (CEUs) in accordance with the rules & regulations of the International Association for Continuing Education & Training (IACET). IACET is an international authority that evaluates programs according to strict, research-based criteria and guidelines. The CEU is an internationally accepted uniform unit of measurement in qualified courses of continuing education.

  Haward Technology Middle East will award **3.0 CEUs** (Continuing Education Units) or **30 PDHs** (Professional Development Hours) for participants who completed the total tuition hours of this program. One CEU is equivalent to ten Professional Development Hours (PDHs) or ten contact hours of the participation in and completion of Haward Technology programs. A permanent record of a participant's involvement and awarding of CEU will be maintained by Haward Technology. Haward Technology will provide a copy of the participant's CEU and PDH Transcript of Records upon request.

- British Accreditation Council (BAC)

  Haward Technology is accredited by the **British Accreditation Council** for **Independent Further and Higher Education** as an **International Centre**. BAC is the British accrediting body responsible for setting standards within independent further and higher education sector in the UK and overseas. As a BAC-accredited international centre, Haward Technology meets all of the international higher education criteria and standards set by BAC.

Course Fee
As per proposal

Course Contents

- Water Injection Technology: Water Flooding A-Z
- Introduction
- Why this Course?
- Waterflooding - General Discussion Important Issues
- Expected Outcome
- Course Description
- Course Outline
- A Typical Waterflood Project
- Waterflood Configurations
- Management Team
- Synergy
- Field Life Cycle
- General Definitions
- Exploration
- Introduction
- Reservoir Management Approach
- Oil Production Processes
- Primary Recovery
- Water Injection System
- Thermal EOR Methods
- Non-Thermal EOR Methods
- Average Recovery Factors
- Types of Data
- Factors Common to all Recovery Methods
- Rock and Fluid Properties
- Factors Common to All Recovery Methods
- Porosity
- Classification of Porosity
- How to Measure Porosity
- Measurement of Porosity with Cores

- Porosity Measurements
- Effect of the Depth on Porosity
- Permeability
- Flow Equation (Darcy Law)
- Porosity Permeability Cross Plot
- Relative Permeability
- Oil-Water Relative Permeability
- Oil-Gas Relative Permeability
- Relative Permeability
- Relative Permeability Curve @ Zero IFT
- Laboratory Methods for Measuring Relative Permeability
- Laboratory Procedure, Displacement (Unsteady-State) Method
- Unsteady State Techniques
- Factors Affecting Effective and Relative Permeabilities
- Effect of Wettability
- Effect of Saturation History
- Choosing the Right Curve
- Importance of Relative Permeability Data
- Capillary Pressure
- Capillary Pressure Curve
- Relation Between Capillary Pressure and Fluid Saturation
- Using of RFT Data to Calculate FWL
- Capillary Pressure Data Applications
- Effect of Permeability on Capillary Curve
- Effect of Contact Angle
- Effect of Interfacial Tension
- Effect of Density Difference
- Effect of Saturation History
- Typical Drainage and Imbibition Capillary Pressure Curves
- Laboratory Methods for Measuring Capillary Pressure
- Wettability
- In Hydrocarbon Reservoirs
- Contact Angle

- Implications of Wettability
- Laboratory Measurement Techniques
- Nonwetting Phase Fluid
- Additives that can Alter Rock Wettability
- Implications of Wettability
- Relative Permeability
- Reservoir Fluid Properties
- Reservoir Hydrocarbon Fluid Classification
- Black Oils
- Phase Diagram For Black Oil
- Volatile Oils
- Retrograde Condensate Gas
- Phase Diagram for Retrograde Gas
- Wet Gas
- Dry Gas
- Phase Diagram for Dry Gas
- Oil Properties
- Typical Shape – Oil Formation Volume Factor
- Solution Gas/Oil Ratio
- Dependence of Oil Viscosity on pressure
- Oil Density
- Water Properties
- Water Salinity
- The Influence of the Reservoir Characteristics
- A Basic Horizontal Well
- The Influence of the Fluid Characteristics
- Reserves Estimation and Classification
- Why Reserve Estimates?
- Oil Reserve Classification
- Remaining Reserves
- Definition
- Proved Reserves
- Definitions

- Reserve Status Categories
- Proved Undeveloped Reserves
- Oil Reserve Classification
- Unproved Reserves
- Definitions
- Possible Reserves
- Energy Source Criteria for Oil Reserve Classification
- Reserves Changes
- Placing Proved, Probable, and Possible on the Distribution
- Reserves-to-Production Ratio
- Role of Reserves
- Reserves Estimates
- Method Used for Estimating Dependent on Data
- Original Oil and Gas in Place Calculation
- Recovery and Efficiency Calculations
- Analogy Method
- Correlations
- Waterfloods
- Ultimate Recovery
- Decline Curve Analysis
- Reservoir Simulation
- Example Applications of Reservoir Simulation
- Steps in a Reservoir Simulation Study
- Reservoir Drive Mechanisms and Producing Characteristics
- Oil Reservoir Drive Mechanisms
- Gas Reservoir Drive Mechanisms
- Reservoir Energy Sources
- Solution-Gas Drive in Oil Reservoirs
- Well & Reservoir Inflow Performance
- Formation of a Secondary Gas Cap
- Dissolved gas drive
- Solution Gas Expansion Characteristics
- Solution Gas Drive

- Solution-Gas Drive in Oil Reservoirs
- Gas-Cap Drive in Oil Reservoirs
- Gas Cap Drive
- Well & Reservoir Inflow Performance
- Water Drive in Oil Reservoirs
- Strong Water Drive
- Water Drive Expansion Characteristics
- Water Drive in Oil Reservoirs
- Combination Drive in Oil Reservoirs
- Gravity Drainage in Oil Reservoirs
- Gravity Drainage
- Gas Reservoir Drive Mechanisms
- Volumetric Gas Reservoirs
- Water Drive in Gas Reservoirs
- Oil Reservoir Drive Mechanisms
- Average Recovery Factors
- Properties Favorable for Oil Recovery
- Characteristics of Various Driving Mechanisms
- Estimating Oil Recovery Factors
- Applications of Waterflooding
- Effects of Gravity
- Lateral Pay Discontinuities
- Attic Gas Injection
- Exercises Recovery Methods
- Exercise
- Exercise
- Describing Water Flooding
- Objectives
- Reservoir Life Cycle
- Infill Drilling
- Waterflooding
- History of Waterflooding
- Reasons for Water Injection

- Pressure Maintenance
- Displace Oil with Water
- Primary Drive Mechanisms
- Proposed and Conditions of Gas and Water Injection
- A Typical Water Flood Project
- Source Waters
- Main Sources of Injection Water
- Injection Water
- A Typical Water Flood Project
- Crude Oil Dehydration
- Difficult Emulsions
- Produced Water Management Disposal Options
- Produced Water Management
- Typical Water Quality Criteria
- Treatment of Water for Waterflooding
- pH of Natural Waters
- Waterflood Performance Measurements
- Water Flood Planning in an Economic Perspective
- Optimum Timing for a Water Flood
- Key Questions in Designing a Water Flood
- Water Injection to Sweep Oil
- Pattern Configurations
- Peripheral or Repeating Pattern Flood
- Peripheral Flood
- Waterflood Patterns
- Repeating Pattern Flood
- Basic Flood Patterns
- Basic Flood Pattern Guidelines
- Peripheral Flooding
- Optimum Water Flood Pattern
- Line Drive Patterns
- 5-Spot Pattern
- 7-Spot Pattern

- 9-Spot Pattern
- Factors in Pattern Selection
- Factors Affecting Pattern Selection
- Design Aspects
- Conceptual Planning
- Preliminary Designs
- Waterflood Design Procedure
- Screen Reservoir for Suitability
- Estimate Injection Requirement to Support the Desired Production Rate
- Select Possible Scenarios
- Why do Waterfloods Fall Below Expectations
- Frontal Advance Theory
- Fractional Flow Equation
- Fractional Flow of Water is Affected by
- Oil-Water Relative Permeability
- Fractional Flow Curves
- Information from the Fractional Flow Curve
- Example
- Example Solution
- Analyzing Waterflood Patterns
- Mobility
- Significance of Mobility Ratio
- Mobility Ratio
- Mobility Ratio Effects
- Significance of Mobility Ratio
- Fluid Displacement in Piston-Like
- Buckley-Leverett
- Waterflood Performance Efficiencies
- Displacement Efficiency
- Laboratory Work
- Performance Efficiencies
- Linear Flow Models
- Example Displacement Efficiency Calculation

- Example: Solution
- Areal Sweep Efficiency
- Areal Sweep Efficiency After Breakthrough
- Vertical Sweep Efficiency
- Mathematical Models of Vertical Sweep Efficiency
- Volumetric Sweep Efficiency
- Performance Predictions
- Methods
- Analogy
- Empirical Techniques
- Analytical Techniques
- Material Balance
- Simulation Technique
- Waterflood Monitoring and Management
- Reservoir Management Process
- Waterflood Monitoring and Management
- On-Line Monitoring
- Waterflood Surveillance
- Waterflood Performance Problems
- Improved Waterflood Strategies
- Monitoring Water Supply
- Factors Affecting Water Quality
- Objective of Pilot Tests
- Pilot Test Design
- Injection & Production Profile Modification
- Problem Solving
- Infill Drilling
- Waterflood Challenges
- Polymer Flooding
- Oil Production Processes
- Non-Thermal Methods
- Non-thermal oil recovery methods
- Polymer Flooding

- Functions
- Principle and Method Description
- Importance of Mobility Control
- Polymer Flooding
- The advantages of polymer flooding
- What is a Polymer?
- Example: Polyacrylamide (PAM)
- Types of Polymers
- Natural Polymers
- Modified Polymers
- Synthetic Polymers
- Polyacrylamides (HPAM).
- Polysaccharides Biopolymers
- Properties of Polymer Solutions
- Stability
- Method Description
- Field Projects
- Polymer Retention
- Effect of Polymer Retention
- Salinity
- Guidelines for Polymer Application
- Fluid Characteristic
- Screen Criteria of Polymer
- Process of Flooding
- Surfactant Flooding Method
- Introduction
- Statement of the Problem
- Objective of the Study
- What is Surfactant
- The Surfactants
- Principle and Characteristics
- Examples of Common Surfactants
- Behavior of the Anionic Surfactant in the Aqueous Phase

- Different Structures of the Micelle Inside the Aqueous Solution
- Description of Process
- Used Martials
- Characterization of Surfactant
- Chromatographic Interpretation Determination of Molecular Weight
- Determination of Chemical Properties
- Variation of Conductivity with Surfactant Concentration
- Product of Solubility (Ps)
- Typical Precipitation Curve (Pure Surfactant)
- Screening Criteria
- Economics of Process
- Review of Field Development Optimization of Waterflooding, EOR, and Well Placement Focusing on History Matching and Optimization Algorithms
- Introduction
- History Matching for Waterflood and Enhanced Oil Recovery
- Production Optimization for Waterflood and Enhanced Oil Recovery
- Benchmark Models
- Conclusions and Future Work