COURSE OVERVIEW DE0624
Reservoir Requirements - Fundamental (E-Learning Module)

Course Title
Reservoir Requirements - Fundamental (E-Learning Module)

Course Reference
DE0135

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 is designed to provide participants with a detailed and up-to-date overview of water flooding, reservoir souring and water breakthrough. It covers the basic concepts of reservoir souring and water breakthrough; the operational troubleshooting techniques to arrive to the cause and to eliminate it through a solution development; the process and equipment problems including past problems associated with start up, shut down, ESD and standard non-compliance; and the prolonged feed specification, sea water and effluent water quality and chemical dosage problems.

Further, the course will also discuss the pressure management and problems; the factors affecting waterflood success; the types of oil reservoirs more favorable for water flood; the integrity management in water injection wells; the water flood plant injection water quality and chemical treatment; the annulus pressure management, water injection problems and injection well integrity; the injection profiles, drilling patterns and reservoirs response to water influx; the water lifting/transfer from source location and filtration and chemical injection; the water property monitoring/recording; the high pressure and high flow rate pumping equipment; installing and operating temporary injection facilities; the optimization of chemicals and quality control; and the water treatment plant operator, water sources and treatment.

During this course, participants will learn the reservoir management and intake structures; the types of water problems, corrosion control and tools of diagnosis the water problems; the methods of water control; monitoring and analysing water production; the water separation and treatment; the layouts of field production facilities, scale, bacteria and corrosion problems; the water treatment methods and corrosion monitoring; the chemical treatment and corrosion control; and the role of operations optimizations to avoid corrosion.

Course Objectives

At the end of this course, the Trainee will be able to:-

- Apply and gain a fundamental knowledge on reservoir requirements
- Explain the purpose of the water flooding process
- Describe the requirements for water quality and target volumes
- Describe water specifications such as TSS (Total Suspended Solids), OIW (Oil in Water), Dissolved Oxygen, etc
- Explain the KOC operational procedures and standards for collecting samples from various wellheads and waterlines for delivery to the laboratory for analysis
- Apply KOC operational procedures and standards for routine sampling
- Report abnormalities and off spec results in order to take appropriate actions
- Describe the purpose of chemical injection in the water treatment process
- Be competent to understand reservoir souring and water breakthrough issues for sea water and effluent water injection wells of Water Handling Facilities (CIF & CIPF Extension)
- Monitor and understand different operational parameters as well as eliminate the source of trouble in a structured manner
- Discuss basic concepts of reservoir souring and water breakthrough
- Identify and define reservoir souring and water breakthrough
- Apply operational troubleshooting techniques to arrive at the cause and eliminate it through a solution development
- Carryout process and equipment problems and include past problems associated with start-up, shut down, ESDS and standards non-compliance
- Recognize prolonged feed specification, sea water, effluent water quality and chemical dosage problems
- Identify pressure management and problems, water flood example, factors affecting waterflood success and types of oil reservoirs more favorable for water flood
- Apply integrity management in water injection wells
- Employ annulus pressure management and discuss water injection problems and the injection well integrity

- Determine injection profiles, design drilling patterns and determine the reservoirs response to water influx
- Illustrate water lifting/transfer from source location, filtration, chemical injection and water property monitoring/recording
- Identify high pressure, high flow rate pumping equipment as well as install and operate temporary injection facilities
- Optimize chemicals and quality control and recognize the water treatment plant operator
- Carryout water sources and treatment, reservoir management and intake structures
- Recognize the types of water problems and corrosion control, tools of diagnosis the water problems and methods of water control
- Monitor and analyze water production and illustrate water separation and treatment including layouts of field production facilities
- Identify scale, bacteria and corrosion problems and apply water treatment methods and corrosion monitoring
- Carryout chemical treatment and corrosion control and discuss the role of operations optimizations to avoid corrosion

Who Should Attend

This course provides a basic overview of all significant aspects and considerations of water flooding, reservoir souring and water breakthrough for water handling field operators, production engineers, petroleum engineers, reservoir engineers, chemists and water flood operators who need to understand water problems in water flooding project.

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

- Understand Water Flooding, Reservoir Souring and Water Breakthrough
- Course Objectives
- Water Flooding the Basics & Discussion
- A Typical Waterflood Project
- Management Team
- Synergy
- Field Life Cycle
- General Definitions
- Exploration
- Introduction
- Reservoir Management Approch
- 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
- Porosity
- Classification of Porosity
- How to Measure Porosity
- Measurement of Porosity With Cores
- Porosity Measurements
- Effect of the Depth on Porosity
- Permeability
- Darcy Law
- Flow Equation (Darcy law)
- Porosity Permeability Cross Plot

- Relative Permeability
- Oil-Water Relative Permeability

- Oil-Gas Relative Permeability
- Laboratory Methods for Measuring Relative Permeability
- Laboratory Procedure, Displacement (Unsteady-State) Method
- Relative Permeability
- Unsteady State Techniques
- Factors Affecting Effective and Relative Permeabilities
- Effect of Saturation History
- Importance of Relative Permeability Data
- Relative Permeability
- Capillary Pressure
- Capillary Pressure Curve
- Relation Between Capillary Pressure and Fluid Saturation
- 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
- Wettability
- In Hydrocarbon Reservoirs
- Contact Angle
- Implications of Wettability
- Laboratory Measurement Techniques
- Nonwetting Phase Fluid
- Additives that can Alter Rock Wettability
- Reservoir Fluid Properties
- Reservoir HC Fluid Classification
- Black Oils
- Phase Diagram For Black Oil
- Volatile Oils
- Retrograde Condensate Gas
- Phase Diagram for Retrograde Gas
- Wet Gas

- Phase Diagram For Dry Gas
- Oil Properties
- Solution Gas/Oil Ratio
- Oil Viscosity
- Oil Density
- Water Properties
- Water Salinity
- The Influence of the Reservoir Characteristics
- Water Flooding Description
- 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
- Oil-Water Relative Permeability
- Fractional Flow Curves
- Information From the Fractional Flow Curve
- Solution

- Analyzing Waterflood Patterns
- Mobility
- Significance of Mobility Ratio
- Mobility Ratio
- Mobility Ratio Effects
- Fluid Displacement in Piston-Like Manner
- Fluid Displacement in Piston-Like
- Buckley-Leverett
- Waterflood - Performance Efficiencies
- Displacement Efficiency
- Laboratory Work
- Performance Efficiencies
- Linear Flow Models
- Displacement Efficiency Calculation
- Areal Sweep Efficiency (E_A)
- Areal Sweep Efficiency After Breakthrough
- Vertical Sweep Efficiency
- Mathematical Models of Vertical Sweep Efficiency
- Performance Predictions Methods
- Analogy
- Empirical Techniques
- Analytical Techniques
- Material Balance
- Simulation Technique
- Course Recap
- Reservoir Souring & Water Breakthrough
- Reservoir Souring
- Corrosion
- Solutions
- Mineral Scavenging
- Colony Establishment of SRB
- Water Breakthrough
- Factors Affecting the Water Break Through

- Water Injection Pump
- Course Recap
- Waterflood Monitoring and Management
- Reservoir Management Process
- 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
- Course Recap
- Polymer Flooding
- 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 are two-fold
- What is a Polymer?
- Polyacrylamide (PAM)
- Types of 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
- Surfactant Flooding Method
- 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
- Course Recap
- Performance of Oil Water Separators
- Produced Water Treatment

- Scale Compositions
- Mixing Formation Water and Seawater - *North Sea (BP Forties) example*
- Barium Sulphate Scaling Tendency
- Calcium Carbonate Scaling Tendency
- Calcium Carbonate
- Calcium Sulphate
- Calcium Sulphate Scale
- Strontium Sulphate
- Solubility of $SrSO_4$ in NaCl Solutions at 25 ^oC
- Barium Sulphate
- Solubility of $BaSO_4$ in NaCl Solutions
- Iron Sulphides
- Scale Prediction – Calcium Carbonate
- Scale Prediction – Strontium Sulphate
- Scale Inhibition
- Scale Inhibition Chemicals
- Scale Inhibitor Evaluations
- Scaling Test Rig
- Alundun Core
- Effect of Scale Inhibitors
- Methods of Application of Scale Inhibitors
- Water Injection Plant Design
- Typical Sea Water Injection System
- Volume
- Pressure
- Corrosion Issues
- Galvanic Corrosion
- Copper Pipework
- Variations in 90/10 Cu/Ni Specifications
- Effect of Iron on Cu-Ni Corrosion
- Corrosion by Dissolved Gases
- Corrosion Process
- Corrosion Management

- Materials of Construction
- Pitting Resistance Number
- Seawater Winning
- Depth of Water Intake
- Winning Pumps
- Chlorination
- Hypochlorite Generating Cell
- Chlorine Breakpoint
- Interference with Chlorination
- Effect of Chlorine
- Course Recap
- Water Injection Treatment & Effect of Flow on Chlorination
- Effect of Flow on Chlorination
- Raw Seawater Handling
- Materials in Seawater Service Velocity Limitations (m/s)
- Galvanic Series in Seawater
- Non-Metallic Materials
- Filtration
- Need for Filtration
- Plankton
- Common Types of Algae
- Growth Limitations of Water Borne Bacteria
- Limiting Nutrients
- Using a Microemulsion to Improve Water Injectivity
- Zooplankton
- Diatoms
- Cocopods
- Filtration Systems
- Need for Filtration
- Filtration
- Hiperfilter Internals
- Polyelectrolytes
- Deaeration Systems

- Typical Sea Water Injection System
- Oxygen Removal
- Oldfield & Todd Equation
- Gas Stripping
- Effect of Flow Rates on Residual Oxygen
- Vacuum Stripping
- Typical Seawater Deaeration Column
- Three Stage Vacuum Tower
- Pressure Profile Across an Air Ejector
- Chemical Scavenging
- Chemical Removal of Oxygen
- Excessive Scavenger
- Combination Effect of pH and Oxygen on Corrosion of Steel
- Effect of Chlorine and Velocity on Corrosion of Steel Oxygen Concentration 30 to 100 ppb
- Weldment Corrosion
- Water Injection Operating Philosophy
- Operating Philosophy
- Injection Well Operations
- Water Quality
- Typical Water Quality Criteria
- Injection Water Quality
- Water Treatment Technologies
- Treatment of Water for Waterflooding
- Aquifer Water
- Water Injection Plant Design
- Volume
- Pressure
- Clay Analysis
- Mixing Formation Water and Seawater
- Calcium Carbonate
- Corrosion Issues
- Water Quality Monitoring
- SRB Growth Media

- Delivery System
- On-Line Monitoring
- Course Recap
- Delivery System & Pumps
- Delivery System
- HP Injection Pumps
- Cavitation in HP Pumps
- Water Quality Monitoring
- Z-Curves
- Standard Millipore Plots
- Completion Materials
- Loss of Injectivity
- Acid Treatment
- Normal, Uncontrolled Acid Squeeze
- Foam Diverted Acid Squeeze
- Using a Microemulsion to Improve Water Injectivity
- Evaluating Methods for Improving Injectivity
- Improving Injectivity
- Forties Trials
- Pipeline Failure Mode
- Microbiological Corrosion caused
- % Sweet Corrosion Failure Mechanisms
- Sulphate-Reducing Bacteria – SRB
- Bacterial Cell Structure
- Bacterial Growth Curve
- Temperature Tolerance
- Water Activity and Potential
- Sulphate-Reducing Bacterium (SRB)
- Growth Rate of Bacteria
- SRB Growth Media
- Typical SRB Growth Medium - Modified Postgate B
- Most Probable Number
- Agar Slopes

- Evaluation of Microbial Corrosion
- Bacterial Growth in Pipelines
- Evaluation of SRB Numbers
- SRB Infection Rating
- Rapid Analysis Methods
- Microscope Counts
- Haemocytometer Slides
- ATP Bioluminescence
- Course Recap
- Bacteria in Produced Water Corrosion
- Evaluations of Sessile Bacteria in Produced Water
- Chemical Analysis
- Corrosion in Pipelines
- Cathodic Protection
- Sacrificial Cathodic Protection
- Available Anode Materials
- Impressed Current Cathodic Protection
- Available Impressed Current Anode Materials
- Internal Impressed Current CP
- CATHODIC PROTECTION of a Water Storage Tank
- Future Developments?
- Changes in Water Source
- Reservoir Water Flood Control
- Reservoir Compaction
- Sulphate Removal from Injected Water
- Welding Lined Linepipe
- Interference Fit Connections
- Glass Reinforced Epoxy Pipe
- Course Recap
- Injection Well and Integrity Annuli Management
- Morgan Waterflood Plant Chemical Treatment
- Morgan Waterflood Plant Injection Water Quality
- A Annulus Pressure Management

- Annulus Pressure Build Up during Shut-In a Water Injector (North Sea water injector)
- Annulus Pressure Bleed Off Procedure
- Well Integrity Management
- Presentation High Frequency Ultrasound Tool
- Course Recap
- Kuwait Case Study
- Lessons Learned from WI Experience for 20 Years
- Injection in Kuwait Case Study
- Water Injection Management
- Water Management
- Management
- Future Plans 7 Projects
- Lessons Learned from the Past Two Decades of Water Injection in NK