COURSE OVERVIEW DE0905

Advanced Hydraulic Fracturing (E-Learning Module)

Course Title
Advanced Hydraulic Fracturing (E-Learning)

Course Reference
DE0905

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 advanced hydraulic and simulation. It covers the advanced hydrofrac technologies (AHT) including its methodology, improved hydraulic fracturing process and evolution of AHT technology; the simplified and ideal versus complex reality of hydraulic fracturing; the hydraulic fracture execution covering conventional approach and AST approach; and the myths and truths about AHT including the challenges for technology application, economic benefits, examples and expectations.

During this interactive course, participants will learn the candidate selection, reservoir description and economic optimization; the pre-fracture design and diagnostic injections for real data-real time, optimization, evaluation and execution; the treatment execution during on-site quality control, inventory control and monitoring of chemical additives; and the post-fracture analysis and calculation of benefits of advanced hydraulic fracturing.

Course Objectives

After completing the course, the employee will:-

- Apply and gain an advanced knowledge on hydraulic and simulation
- Understand rock properties and rock mechanics related to fracturing applications
- Better understand fracturing fluid mechanics and proppant transport
- More effectively design fracturing treatments through better understanding of factors influencing hydraulic fracturing applications
- Use pre-frac injection test data and real-time fracturing treatment data in fracturing applications to define fracture parameters and improve frac treatment design
- Consider factors influencing post-frac fracture conductivity and well cleanup
- Realize the strengths and limitations of existing hydraulic fracturing technology and fracture models
- Expand fracturing applications to fit a wider range of reservoir types and conditions
- Discuss the advanced hydrofrac technologies (AHT) including its methodology, improved hydraulic fracturing process and evolution of AHT technology
- Describe the simplified and ideal versus complex reality of hydraulic fracturing
- Carryout hydraulic fracture execution covering conventional approach and AST approach
- Explain the myths and truths about AHT including the challenges for technology application, economic benefits, examples and expectations
- Carryout candidate selection and explain reservoir description and economic optimization
- Illustrate pre-fracture design and diagnostic injections for real data-real time, optimization, evaluation and execution
- Employ treatment execution during on-site quality control, inventory control and monitoring of chemical additives
- Apply post-fracture analysis and calculate the benefits of advanced hydraulic fracturing

Who Should Attend

This course provides an advanced knowledge on hydraulic and simulation for production, operations and completions engineers and supervisors who are actively involved in hydraulic fracturing design, application and analysis and desire a more in-depth understanding of the theoretical and practical aspects.

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

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 Contents

- Advanced Hydraulic Fracturing
- Advanced Hydrofrac Technologies (AHT)
- Introduction to AHT
- Improved Hydraulic Fracturing Process
- Evolution of AHT Technology
- Research and Development Results are Significant
- Implications for Industry
- Simplified and Ideal vs Complex Reality
- Hydraulic Fracture Execution
- Conventional Approach
- AST Approach
- Myths and Truths about AHT
- AHT Methodology
- Challenges for Technology Application
- Economic Benefits of AHT
- Economic impact can be significant
- Dependent upon
- Examples of Benefits

- Expectations for AHT
- Summary
- AHT Methodology
- Candidate Selection
- Previously Stimulated Wells May be Ideal Candidates
- Production Data can be Used to Estimate Permeability
- Reservoir Description
- Reservoir Model Used to Predict Performance
- Fracture Model Used to Predict Treatment Costs
- Calibrated 3D Models Provide Realistic Expectations
- Example Initial Design
- Treatment Design to Pack Fracture
- Typical Fracture Treatment Data
- Diagnostic Injections
- Treatment Execution
- Monitoring of Chemical Additives
- Is Design Being Achieved?
- Calculate Benefits of AHT
- Summary
- Course Recap
- Candidate Selection and Optimization
- Stimulation Objectives and Types
- Objectives of Stimulation
- Reasons to Stimulate
- Types of Treatment: Matrix
- Types of Treatment: Hydraulic Fracture
- Matrix Stimulation Designed to Alter Pressure Drop Around the Well
- Fracturing designed to Alter Flow Patterns
- A Fracture Acts to Increase Effective Radius of Well
- Stimulation Candidates
- Selecting Stimulation Candidates
- Almost Always Good Candidates
- Sometimes Good Candidates

- Never Good Candidates
- It is Essential to Determine the Following Reservoir Properties
- Optimal Use of Matrix Stimulation
- Ideal Reservoir Properties for Fracturing
- Challenging Reservoir Properties for Fracturing
- Optimization of Fracture Treatments
- Economic Indicators
- Methodology and Example
- Optimization Methodology Steps
- Optimization Methodology
- Optimization Considerations
- Dimensionless Fracture Conductivity Can Compare Different Treatments
- Cost of Conductivity
- Example Optimization Study
- Production Forecasts
- Estimate Fracture Costs
- Calculate NPV/IR for Different Cases
- Perform Post-Frac Evaluation
- Develop Simple Relationships for Given Areas
- Candidate Selection Flow Chart
- Course Recap
- In-Situ Stress and Stress Testing
- Definition and Importance of In-Situ Stress
- In-Situ Stress
- Causes of Downhole Compressive Stress
- What Influences Stress at Depth?
- Importance of Stress
- Accurate Stress Data is Required to Determine Net Pressure
- Estimating Stress Orientation
- Methods to Estimate Stress Orientation
- The Tool Assembly
- Over coring
- Anelastic Strain Recovery

- Tiltmeter Arrays
- Estimating Maximum Stress Direction
- Hydraulic Fracture Mapping with Microseisms
- Estimating Stress Magnitude
- Methods to Estimate Stress Magnitude
- Estimating Stress Magnitude
- Most Common Stress Measurement Procedures
- Logs (Indirect)
- Stress Tests (Direct)
- Minifrac (Direct)
- Most Log Methods Based on Modification to Basic Equation
- Basic Stress Equation Based on Linear Elasticity
- Modifications to Stress Equation
- Proposed Modifications to Stress Equation
- Log-Derived Stresses Need to Be Calibrated to Measured Data in an Area
- Modifications to Stress Equation
- Estimating Rock Properties from Logs
- In-Situ Stress
- Other Rock Properties from Logs
- Stress Profiles from Logs
- Lithology-Based Approaches
- Stress from Gamma
- ABC Approach
- Stress Comparison: Gamma Ray and Sonic
- Summary of Log-Based Methods
- Direct Methods
- Direct Methods –Stress Tests
- Typical Stress Test – Pump-in/Shut-in
- Stress Testing Considerations
- Cased-Hole Test Configuration
- Example - Cased-Hole Test Procedure
- Injection/Flowback Procedure
- Flow Pulse Technique to Get Closure Stress

- Example of Flow Pulse Technique
- Minifrac Analysis
- Stress From Minifrac
- Summary of Direct Methods
- Stress Test Analysis
- Stress Test Analysis Techniques
- Fracture Closure
- Closure Pressure Analysis
- Re-Opening Pressure Analysis
- Step Rate Tests
- Developing Stress Profiles
- Uncalibrated Logs Can Have Errors of +/- 20%
- Log Stresses calibrated to Stress Tests
- Calibrated Stress Profile
- Stress Profiling Summary
- Course Recap
- Developing Data Sets
- Fracture Modeling
- 3D Fracture Modeling
- Results from 3D Models
- Input “Data” Requirements for All Fracture Models
- Additional Data Requirements for 3-D Fracture Models
- Additional Data Requirements for Fracture Treatment Optimization
- Measured or Estimated Parameters
- Controlled Parameters
- Sources of Data
- Reservoir Data – Permeability
- Methods to Estimate Permeability
- Production Data Can Be Used to Estimate Permeability
- Reservoir Data - Reservoir Pressure
- Reservoir Data - Gross Net Pay
- Fluid Properties
- Example Rheological Data

- Measurement of Wall Building Coefficient (Cw)
- Total Leakoff is a Function of Cw, Cc and Cv
- Example Friction Data
- Proppant Properties
- Fracture Conductivity
- Estimating Young's Modulus
- Poisson's Ratio and Young's Modulus for Various Rock Types
- Young's Modulus
- Low vs. High Young's Modulus
- Poisson's Ratio
- Rock Properties from Logs
- Static vs. Dynamic Young's Modulus
- Fracture Toughness of Rock
- Lithology Based Databases
- Stress and Permeability Profile
- Mechanical Properties Profile
- Pre-Fracture Analysis
- Pre Fracture Well Analysis
- Formation Permeability
- Methods to Estimate Permeability
- Pressure Transient Analysis
- Type-Curve Analysis
- Results from Pressure Transient Analysis
- Potential Complexities
- Production Data Analysis
- Fetkovich Type Curve
- Analytical Models
- Fracture Treatment Optimization
- Simulator History Matching
- Analysis of Single Point Flow Data
- Basis for Technique
- Transient Radius of Drainage (TRD) Equation
- PSS Solution to Diffusivity Equation

- Analysis Methodology
- Data Requirements
- Major Assumptions in Analysis
- Wellbore Storage Distortion of Results
- Error if Assumed Skin is Wrong
- Horner Best for Constant Pressure Tests
- Summary
- Course Recap
- Critical Concepts
- Simplified Fracture Problem
- Deformation of a Bar Due to Uniaxial Compressional Load
- Opening of A Fracture Due to Internal Pressure
- Typical Mechanical Properties of Rock
- Fluid Viscosity
- Flow Profile Depends on Fluid Rheology
- Laminar Fluid Flow Through Parallel Plates
- Fluid Flow Sensitive to Fracture Width: q Proportional to w Cubed
- Calculation of Fracture Equilibrium Condition
- Pressure Profile in Fracture in Equilibrium Condition
- Basic Equations for Fracture in Equilibrium Conditions
- Necessary Pressure to Keep Fracture in Equilibrium
- Well Pressure Pw = Fourth Root of Q
- Fracture Initiation and Propagation
- Fracture Initiation
- Pressure Profile Propagating in Fracture
- Toughness Important for Fracture Initiation
- Stress Effects
- Closure Stress Profile
- 3D State of Stress
- Reservoir State of Stress Impacts
- Preferred Fracture Plane
- Preferred Fracture plane Usually not Aligned with Well Orientation
- Fracture Grow along Tension Faults

- Fractures Grow Normal to Strike-Slip Faults
- Fractures May Grow Horizontal near Compressional Faults
- Fractures Grow Towards a Mountain Range
- Mechanisms for Re-orientation of Propped Re-fracture Treatments
- Effective Stress
- Depletion Results in Increased Effective Stress and Decreased Total Stress
- Pore Pressure Variations Change Fracture Orientation
- Fracture Modeling
- Motivation for Fracture Growth Modeling
- Physical Process
- Different Models
- 2D Models
- Pseudo 3D Models
- Lumped 3D Models (Fracpro)
- Full 3D Models
- Non-Planar 3D Models
- Example for Comparison for Models
- PKN - Model - Very Long Confined Fractures
- CGD - Model - Very Long Confined Fractures
- Radial Model (Linear Elasticity) - Long Thin Fractures
- 3D-Model (Dilatant) Short Wide Fractures
- Pressure Matching
- Balloon Analogy for Opening Fracture with Constant Radius
- Fracture Geometry Changes with Net Pressure
- Estimating Frac Dimensions Using Real Data, Radial Frac Assumption
- Influence of Net Pressure
- Real-Data Fracture Treatment Analysis
- Net Pressure Matching
- Surface Injection parameters – Surface Pressure, Flow Rate, Proppant Concentration
- Net Pressure vs. Friction Pressure
- Calculating Net Pressure from Surface Pressure
- Wellbore Friction (for Turbulent Flow)

- Perforation Friction is a function of Flow Rate Squared
- Near-wellbore Friction Varies Roughly with Square Root of Q
- Matching Observed and Model Net Pressure
- Tip Effects
- Tip Effects Increase Fracture Growth Resistance
- What are Tip Effects?
- What is Dilatancy? Expansion of Rock at Large Differential Stress
- Dilatancy For Large Differential Stress Near Fracture Tip
- Consequences of Tip Effects
- Multiple Hydraulic Fractures
- What are Multiple Hydraulic Fractures?
- Multiple Overlapping Hydraulic Fractures
- Multiple Independent Hydraulic Fractures: Reduced Dimensions and Width
- Consequences of Multiple Independent Hydraulic Fractures
- Minimizing Multiple Hydraulic Fractures
- Fracture Height Growth
- What is Fracture Height Growth?
- Equilibrium Fracture Height
- Height Growth Due to Leverage
- Excess Height Growth Example: Treatment Data
- Excess Height Growth Example: Net Pressure for Main Treatment
- How is Height Growth Affected by Permeability Barriers?
- Height Confinement from Adjacent Layers with High Permeability
- Consequences of Fracture Height Growth
- Proppant Convection
- Downward Proppant Transport
- Convection is Downward Proppant Transport of Dense Slurry
- Mechanics of Proppant Convection
- When does Proppant Convection Occur?
- Proppant Convection is Faster Than Proppant Settling
- Encapsulation Accelerates Proppant Convection
- Consequences of Proppant Convection
- To Minimize Proppant Convection Reduce Closure Times

- Near-Wellbore Tortuosity
- Causes of Near-Wellbore Fracture Tortuosity
- Tortuosity: Width Restrictions Close to Well
- Near-Wellbore Tortuosity Can Occur in Open Hole Testing
- What is Tortuosity? Simple Tortuosity Model
- When Does Near-Wellbore Fracture Tortuosity Occur?
- Tortuosity Occurs in Biased Stress Fields
- Increased Screen-Out Risk for Large Perforated Intervals
- Consequences of Near-Wellbore Fracture Tortuosity
- Tortuosity Can Be Measured: Diagnostic Injections
- Tortuosity Can Be Measured: Stepdown Test
- Tortuosity Can Be Measured: Diagnostic Injections
- Tortuosity Can Be Measured: Stepdown Test
- Perforation Friction Dominated Regime
- Tortuosity Can Be Measured: Stepdown Test
- Near-wellbore friction dominated regime
- Minimizing Tortuosity (and Premature Screen-Outs)
- Tortuosity Can Be Removed Using Proppant Slugs
- Fluid and Proppants
- Fluid Properties
- Properties of a Fracture Fluid
- Density
- Friction
- pH
- What is Viscosity?
- Shear Stress and Shear Rate for Different Models
- Fracturing Fluids are Typically Described with Power Law Model
- Modeling of Foams
- Viscosity at a Known Shear Rate
- Typical Shear Rates During Fracturing
- Estimating Fluid Viscosity in Fractures
- Viscosity Measurements
- Typical Viscosity Values

- Example Rheological Data
- Measurements of Apparent Viscosity
- Fluid Loss Equations
- Measurement of Wall-Building Coefficient (Cw)
- Effect of FLA on Wall-Building Fluid Loss Coefficient
- Total Fluid Loss C_t
- Effect of Fluid Efficiency
- Fluid Efficiency
- Types of Fracture Fluids
- Requirements of a Fracturing Fluid
- Fracturing Fluids and Additives
- Fracturing Fluid Types
- Water Based Fluids
- Foam Based or Energized Fluids
- Oil Based Fluids
- Acid Based Fluids
- Linear Gel Fluids
- Polymers
- Polymer Residue (By Weight)
- Relative Cost of Polymer
- Example Viscosity Curve for Linear HPG Gel
- Crosslinked Gelled Fluids
- Cross-Linking Agents
- Crosslink Mechanisms
- Timing of Crosslink Reaction
- Crosslinked Systems
- Commonly Used Crosslinkers
- Viscosity Affected by Polymer and Crosslinker
- Viscosity at Various Temperatures
- Energized Fluid
- Foamed Fluids
- Foam Fracturing Fluids
- Nitrogen (N2)

- Carbon Dioxide (CO_2)
- Variations
- Binary (Both N_2 And CO_2)
- Properties of Gases Used in Foams
- Foam Stability
- Foam Texture
- Foam Half Life Drain Time
- Foam Quality Affects Foam Viscosity
- Foam Quality
- Example of Foam Quality Calculation
- Constant Internal Phase vs. Conventional Quality
- Fracture Fluid Additives
- Typical Fracturing Fluid Additives
- Additive Compatibility
- Biocides
- Breakers
- Conditions for Breakers
- Oxidizer and Enzyme Breakers
- Effect of Oxidizer Breaker Loading on Viscosity
- Buffers
- Surfactants
- Clay Stabilizers
- Fluid Loss Additives
- Diverting Agents
- Summary of Chemical Additives
- Biocide
- Breaker
- Buffer
- Clay stabilizer
- Diverting agent
- Fluid loss additive
- Friction reducer
- Iron controller

- Surfactant
- Gel stabilizer
- Selection of Fracture Fluids
- Select Type of Fracture Treatment
- Fracturing Fluids and Conditions for their Use
- Selecting a Fracturing Fluid
- Fracture Propping Agents
- Ideal Properties
- Proppant Types
- Fracture Conductivity at Reservoir Conditions
- Dimensionless Fracture Conductivity
- Optimum Conductivity
- Effective Closure Stress On Proppant
- Fracture Conductivity in Reservoir
- Fracture Conductivity for Different Proppants
- Percent of Retained Conductivity
- Types of Proppants
- Sand Varieties
- Resin-Coated Sand
- Ceramics
- Selecting a Propping Agent
- Propping Selection Based on Closure Pressure
- Selection Proppant Mesh Size
- Course Recap
- Quality Control and Supervision
- Introduction
- What is Quality Control (QC)
- Why is Quality Control Important
- Fluid Problems Can Occur
- Optimum Crosslinker Concentration
- Effect of Titanium Crosslinker Age on Viscosity Measurements
- Breaker Testing
- Affects of pH on Fluid Viscosity

- Viscosity Variations
- Pre-Treatment Prep: Equipment
- Pre-treatment Preparation
- Required Equipment
- Monitoring Equipment
- High Pressure Pumping Equipment
- High Pressure Discharge Line
- Blending Equipment
- Blender (Proportioner)
- Pre-Mix Blender
- Isolation Tool (TreeSaver)
- Pre-Treatment Prep: Proppant and Fluid
- Proppant Storage
- Fluid Storage
- Evaluate Well Information
- Pre-Treatment Fluid Testing
- Acceptable Levels of Water Analysis
- Measuring Fracture Fluid Properties
- Viscosity Measurements
- Conventional Fluid Tests
- Base Gel Viscosities
- Base Fluid Viscosity
- Guar Viscosity Variations
- Advanced Fluid Testing
- Pre-Treatment Prep: On Location
- On Location Immediately Before Treatment
- Safety Guidelines
- The Safety Meeting
- Proper Rig Up Procedures
- Review Treatment Proposal (Plan)
- Material Inventory
- Analyze Fluid Properties
- Conventional Tests

- Advance Fluid Tests
- Crosslink Time and Appearance
- Generally
- Realistically
- Analyze Proppant Properties
- Fracture Treatment QC and Monitoring
- Wellbore and Near-Wellbore Hydraulics
- Pipe Friction
- Hydrostatic Pressure
- Perforation Friction
- Tortuosity
- Fracture Diagnostics
- Evaluate Calculation of BHTP
- Evaluate Reservoir Properties
- Instantaneous Shut-In Pressure
- Fluid Efficiency
- Fracture Closure Analysis
- Fracture Closure
- Net Pressure
- Fluid Testing
- Real-Time Monitoring Cross-Checks
- Recording Treatment Parameters
- Slurry Volume
- High Pressure Leak
- Loss of Proppant Addition
- Loss of Chemical Additives
- Fire and Other Catastrophic Events
- Post-Treatment Operations
- Course Recap
- Diagnostic Injections
- Purpose of Diagnostic Injections
- Is Design Post-fracture Production Being Achieved?
- "Typical" Fracture Treatment Data

- Net Pressure Matching Without Diagnostics
- On-Site Treatment Diagnostics
- Purpose of Diagnostic Injections
- Anchor Points for Real-data (Net Pressure) Analysis
- Design and Analysis of Diagnostic Injections
- Example of Treatment with Limited Diagnostics
- Initial Pump-in/Shut-in to Establish Injectivity
- Conventional Pressure Decline Analysis
- Pressure Decline Analysis - Clear Slope Change
- Pressure Decline Analysis – No Clear Slope Change
- Pressure Decline Analysis - Multiple Slope Change
- Second PI/SI Test
- Verifying Friction with Multiple ISIPs
- Typical Step Down Test
- Typical Step Down Test Analysis
- Stepdown Test Example 1: Perforation Friction
- Stepdown Test Example 1: After Perforating
- Field Example of Stepdown Test - Dominant Near-Wellbore Friction
- Flow Pulse Technique to Help Verify Closure Pressure
- Flow Pulse Technique Principle
- Example of the Flow Pulse Technique
- Mini Fracture Treatment
- Mini-Fracture Example
- Mini-Fracture Test: Closure Pressure Analysis
- Match of PI/SI Tests: Redesign the Treatment
- Methods to Estimate Bottomhole Pressure
- Determining Bottomhole Pressure
- Direct Measurement
- Indirect
- Calculated
- Estimating Bottomhole Pressure Using a Deadstring
- Calculation of Net pressure From Surface Pressure
- Calculation of Net pressure: Gelled Oil Example #1

- Match of Net Pressure Using Surface Pressure: Example #1
- Match of Net Pressure Using Surface Pressure: Example #2
- Comparison of Bottomhole Pressures: CO_2 Foam Treatment
- Course Recap
- Real-Time Analysis
- Definition of Real-Time Analysis
- Benefits of Real-Time Analysis
- New Approach to Fracture Design and Execution
- Two Components of Advanced Real-Time Analysis
- Setup for Advanced Real-Time Analysis
- Equipment for Advanced Real-Time Analysis
- Data Communication
- Two Computers
- Software
- Data Flow During Advanced Real-Time Analysis
- Treatment Data Monitored for Advanced RTA
- Minimum Data Requirements
- Beneficial Data
- Accurate Bottomhole Treating Pressure Data
- Impact of Real-Time Analysis
- Net Pressure
- Importance of Net Pressure
- Definition of Net Pressure
- Schematic of Net Pressure
- Calculation of Net Pressure
- Resolving Friction
- Quantifying Total Friction
- Characterizing Near-Wellbore Friction
- Schematic of Model and Observed Net Pressure
- Net Pressure Using Surface Pressure Data
- Net Pressure Using Bottomhole Data
- Obtaining Accurate Bottomhole Data
- Bottomhole pressure gauge

- Deadstring
- Shut-in during pad
- Critical Fracturing Mechanisms
- Adequate Propped Fracture Coverage Across Net Interval
- Mechanisms Preventing Successful Prop Placement
- Possible Result of Mechanisms
- Definition of Proppant Convection
- Schematic of Proppant Convection
- Mathematical Relationship for Proppant Convection
- Methods to avoid Proppant Convection
- Definition of Near-Wellbore Tortuosity
- Schematic of Near Wellbore Tortuosity
- Importance of Near Wellbore Tortuosity
- Identification of Near-Wellbore Tortuosity
- Methods to Minimize of Near-Wellbore Tortuosity
- Definition of Multiple Far-Field Fracturing
- Classification of Multiple Far-Field Fractures
- Parallel Multiple Far-Field Fractures
- Varied Orientation Multiple Far-Field Fractures
- Several Initiation Points Multiple Far-Field Fractures
- Field Evidence of Multiple Far-Field Fractures
- Identification of Far-Field Multiple Hydraulic Fractures
- Methodology for Advanced Real-Time Analysis
- Steps in Advanced Real-Time Analysis
- Example Initial Design
- Step 1. Design Initial Treatment
- Initial design uses estimates of reservoir properties
- Design should include pre-treatment injection tests
- Sufficient fluid and proppant volumes to allow job redesign and modification
- Step 2. Execute Diagnostic Injection Tests
- Pump-in/shut-in (Pi/Si) tests
- Stepdown tests
- Shut-in test

- Additional Pi/Si tests based on previous pi/si results
- Step 3. Measure/Diagnose Critical Frac Parameters
- Closure Stress
- Total Leak-off Coefficient
- Amount of Near-Wellbore Pressure Drop
- Extent of Far-Field Multiple Fracturing
- Step 4. Redesign Fracture Treatment
- Adjust Fluid Viscosity and Rate to Address:
- Optimize Pad Volume Based on:
- Design Proppant Schedule to Investigate or Address Near-Wellbore Fracture Entry Problems
- Step 5. Execute Fracture Treatment
- Evaluate Fluid Character Based on:
- Observe Pressure Response from Proppant Entry into the Fracture
- Execute or Modify Proppant Schedule Based on:
- Record Post-Treatment Pressure Decline
- Real-Time Analysis Summary
- Post-Frac Analysis
- Objective
- Is Design Post Fracture Production Being Achieved?
- Are Field Results Meeting Expectations?
- Post-Fracture Analysis Techniques
- Single Well Analysis
- Individual Well Analysis
- Potential Complexities
- Layering
- Areal and Directional Permeability Anisotropy
- Poorly Designed Well Tests
- Two-Phase Flow
- Verify with Pressure Buildup Tests
- Detect Problems with Fracture
- Evaluate Long Term Performance
- Restimulation May Be Necessary

- Production Data Analysis
- Measure All Production and Pressures
- Comparison of Design to Actual
- Consider Fluid Cleanup
- Benefits of Single Well Analysis
- Multi-Well Analysis
- Well Productivity Indicator
- Best Year Average vs. Cumulative
- AOF vs. 12 Month Cumulative
- Develop Baseline Performance
- Predict Performance
- Predicted vs. Actual Performance
- Benefits from Reduced Screenouts
- Evaluate Technology Application
- Probability Plot of Benefits
- Best Year Difference
- Multiple Well Analysis Summary
- Production Forecasting
- Production Forecasting Methods
- Conventional Decline Curve Analysis
- Empirical Type Curves
- Advanced Decline Curve Analysis
- Reservoir Simulation
- Special Applications
- Production Forecasting Methods
- Production Data Analysis Methods
- Advanced Decline Curve
- Numerical Simulation
- Conventional Decline Curve Analysis
- Uses readily available data
- Used to predict future performance
- Conventional methods not always applicable
- Cannot estimate reservoir properties

- Arp's Hyperbolic Decline
- Formulations for Arp's Equation
- Semilog Rate vs. Time Plot
- Example Exponential Decline Analysis
- Arp's Equation Summary
- Advantages
- Limitations
- Constructing Empirical Type Curves
- Example Empirical Type Curve
- Summary Empirical Type Curve
- Advanced PDA Methods
- Analytical and Empirical Type Curve
- Fetkovich's Dimensionless Variables
- Equivalent Liquid Time
- Type Curves for Gas Wells
- Example Fetkovich Type Curve
- Analytical Reservoir Models
- Analytical Models for Special Applications
- Early Time Data Analysis
- Variable Flowing Pressure
- Reasonably Constant Flowing BHP
- Constant Flowing BHP
- Variable BHP
- Handling Shut-In Periods
- Variable Flowing BHP and Shut-In
- Intermittent Flow - Plunger Lift
- Naturally Fracture Wells
- Other Considerations
- Summary
- Individual well analysis
- Multiple well analysis
- Downhole Mixing Fracturing
- Tool Assembly Downhole Mixing

- CobraMax DM Video
- Course Recap
- Jet Fracturing
- SurgiFrac Tool OD and Rate Limitations
- Self-Suspending Proppant
- Floats and is Transported to Further reaches of Fracture Network
- Course Recap
- Extended Reach Applications
- Completions Considerations Horizontal Shale Wells
- YM, PR, Brittleness
- Zipper Frac
- Modified Zipper Frac
- Course Recap
- Hydraulic Pumping Systems (Vorteq)
- Proppant-Free Channel Fracturing
- Conductivity vs. width open fractures by varying porosity (Parker et al. 2005)
- Large-scale slot model shows how proppant-aggregate beds were transported and distributed
- Comparison of methods for forming proppant-aggregate beds
- Treatment Chart for the PFC Fracturing Treatment in Egypt
- Treatment Chart of a PFC Fracturing Treatment Stage in the Eagle Ford
- Course Recap
- Multi-Stage Horizontal Fracturing Unconventional Reservoirs
- Stimulation Tuning
- Horizontal Drilling from Pad
- Multistage Frac Horizontal Well