WELL COMPLETION TECHNOLOGY

Cased Hole and Production Log Evaluation

COURSE DESCRIPTION:
This 5-day program is a comprehensive and up-to-date course covering the new and traditional wireline diagnostic techniques for the surveillance of cased wells. Topics include:
• Formation evaluation through casing
• Well integrity—cement and casing inspection
• Water identification and fluid movement in both injection and producing wells

WHO SHOULD ATTEND:
This course is for reservoir and production engineers and geologists, petrophysicists, log analysts and others involved in well surveillance, maximizing recovery, identifying production problems, planning workover operations or utilizing production information in reservoir studies.

COURSE MATERIALS:
Bound copy of slides for each attendee, electronic version of course program with examples and reference material; textbook 1996 by Dr. James Smolen, “Cased Hole and Production Log Evaluation”; PLATO Software Demonstration

AGENDA
The following agenda is based on three morning and three afternoon sessions daily, each session approximately one to 1-1/4 hours in length. Note that class problems (PROBLEMS), and movies (MOVIES) have been highlighted. Numerous log examples for class discussion are also presented throughout the course.

DAY 1
Overview of logging operations
- Typical well profile
- Casing and through tubing operations distinguished
- Types of wells/operations
  ▪ Conventional vertical and deviated wells
  ▪ Pumping wells
  ▪ Horizontal wells
Logging horizontal/highly deviated wells
- Pump down systems
- Coiled tubing conveyance
  ▪ Tractoring devices
  ▪ Downhole logging environment
Gamma Ray (GR) Logging
- Open hole/cased hole correlation
- Shale response and shale volume determination *(PROBLEM)*
- Other applications
  - Spectral Gamma Ray
    - Thorium/Uranium/Potassium delineation and applications

**Pulsed Neutron Capture (PNC) Logs**
- Principles of neutron energy, gamma ray emissions, and capture
- Basic formation model
- Ideal log response *(PROBLEM)*

**Pulsed Neutron Capture Logs (Continued)**
- Porosity and salinity limitations *(PROBLEM)*
- Determination of bulk formation capture cross section by logging tools
  - Exponential decay of neutron population
  - Measurement of decay rate and sigma

**Development of the capture technique and log presentation**
- Major service company equipment development
- Primary and secondary log measurements

**DAY 2**

**Computation of saturations--clean and Shaly zones (PROBLEM)**
- Dual water model overview
- Miscellaneous applications of PNC tools
  - Residual Oil Saturation, ROS, by log-inject-log technique

**Detection of Water Flow by Oxygen Activation using PNC tools**
- Water movement from background count rate
  - Water Movement Specific tools/measurements
    - Atlas Hydrolog and Halliburton TMD-L
    - Schlumberger Water Flow Log, WFL *(PROBLEM)*

**Neutron and Compensated Neutron Log, CNL**
- Porosity measurement and gas effect
- Gas Cap monitoring
  - Carbon-Oxygen Measurements
    - Used when salinities are low or unknown
    - Sources of carbon and oxygen counts downhole
    - Inelastic and capture data and log runs
    - Windows vs. Elemental Yields Techniques

**Carbon-Oxygen Measurements (continued)**
- Log presentations (BV, ratios, Ca/Si-C/O overlay)
- C/O envelope from tool characterization data*(PROBLEM)*
- Determination of saturation and holdup for the RST-B *(PROBLEM)*
- New tools (RST, RPM, RMT, RAPTOR)

**Gas-View/Baker Atlas**
- An enhanced Atlas RPM based technique for detecting gas
- **Through-Casing Resistivity** – (CHFR)
  - Tool Theory
  - Stationary measurements
- **Formation Testing Through Casing**
  - Testing using perforations
  - Plugging holes after testing (CHDT)

**Cement Bond Logs**
- **The basic cement bond log**
  - Basic measurements, amplitude, wave train, VDL
  - Tool centralization/quality control using travel time
  - Interpretation of bond quality
  - Effects of microannulus, fast formation, cement curing time

**DAY 3**

**Quantitative Bond Logging**
- Bond Index, BI *(PROBLEM)*
- Fundamental problem with conventional bond logs
- Need to scan laterally
- **Borehole compensated bond logs, CBT, BAL**
  - Advantages over convention CBL measurements

**Pad type bond logs, Atlas SBT**
- Configuration and operation
- Log presentation

**Conventional Bond Logs with Directional capability**
- Slim Cement Mapping Tool (SCMT) and others

**Pulse-Echo Bond Tools**
- UltraSonic Imager, USI
- Circumferential Acoustic Scanning Tool, CAST-V
- **Basic measurements**
  - ID
  - Wall roughness
  - Wall thickness
  - Acoustic impedance of annular material
- **Acoustic Impedance and how it is measured**
  - Log presentation--curves and cement map

**Pulse-Echo Bond Tools (Continued)**
- Log examples
- Effects of microannulus, centralization, and gas-cut cement
- Mobil technique using raw acoustic impedances *(PROBLEM)*
- Micro-Debonding and variance plots

**Isolation Scanner (formerly IBC, Imaging Behind Casing tool)**
- USI plus flexural wave measurements
- Gas, Liquid, Solid identification outside casing
- Polar Plot showing second surface reflection
- Log examples

- **Casing Inspection**
- **Halliburton Borehole Video (MOVIE)**

**Casing Inspection (Continued)**

- **Mechanical Calipers**
  - Bow Spring
  - Multi-finger

- **Electromagnetic pad type tools, PAT, PIT, VERTILOG**
  - Principle of operation
    - Flux leakage test (total wall)
    - Eddy current test (inner surface)
  - Log presentation
    - Basic global and individual pad presentations

- **Phase shift tools, METT, Magnelog, and multiple-sensor thickness tools**
  - Shift proportional to metal remaining
  - Tools with arrays of thickness sensors (12 or 18)

**DAY 4**

- **Continuously Run Spinner Flowmeters in Vertical Wells**
  - Types of Spinners
  - Log data required to be recorded
  - Spinner response under ideal conditions
  - Effects of viscosity and mechanical threshold
  - Detection of bulk fluid movement using spinners

- **Interpretation of Spinner Logs for Bulk Production Profile**
  - **Multipass plot technique (PROBLEM)**
    - Interpretation when only down runs are available

- **Two pass overlay technique (PROBLEM)**
  - Flow profile correction factor
  - Compute bulk production profile (PROBLEM)

- **Fluid Identification Devices for Multiphase Flow**
  - Holdup vs. cut
  - Bulk fluid density
    - Pressure differential tools (Gradiomanometer and dP/dZ)
    - Nuclear fluid density, focused and unfocused
  - Capacitance devices
  - Vibrating reed density sensors
  - Bubble probes (DEFT/Flowview, GHOST, CAT, RAT)
  - Gas Holdup Tool --GHT
  - Other (PNC borehole sigma, borehole C/O, etc.)
  - Slip velocity between the flowing phases
Computation of Two Phase Flow in a Well (PROBLEM)
- Requirements to solve for three phase flow
- Multiphasic flow in deviated wells
  ▪ Marathon study (Liquid-Liquid) (MOVIE)
  ▪ Atlas Flow Loop (Gas-Liquid) (MOVIE)
  ▪ Tools to deal with the deviated multiphase flow environment

High Deviation Angle and Horizontal Multiphase Flow
- Visualization of horizontal flow
  ▪ Schlumberger Cambridge Research Center Video (MOVIE)
  ▪ Schlumberger Flagship Tool String
    o Dual DEFT (Flowview Plus)
    o GHOST-Gas Holdup
    o Non-radioactive gadolinium based tracers for stratified flow
  ▪ Atlas POLARIS Tool String and Atlas Flow Loop (MOVIE)
  ▪ Pulsed Neutron Holdup Indicator (PNHI/RPM)
  ▪ MultiCapacitance FlowMeter (MCFM)
- Schlumberger Flow Scan Imager—(FSI)
- Sondex/Halliburton horizontal flow tools (MAPS)
  ▪ Spinner Array Tool (SAT)
  ▪ Capacitance Array Tool (CAT), Resistance Array Tool (RAT)

DAY 5

Temperature Logging
- Causes of temperature anomalies
  - Temperature logs in producing wells
    - Liquid entries
    - Gas entries
    - Detection of channels
  - Temperature logs in injection wells
    - Special applications--measure induced fracture height and acid placement

Noise Logs
- Stationary noise measurements of noise and frequency
  ▪ Log presentation
  ▪ Determination of single or two phase flow
  ▪ Location of gas-liquid interfaced in the wellbore
  ▪ Detection of moving fluid in channels
  ▪ Review combination noise-temperature surveys

Radioactive Tracer Logging
- Tool configuration for injection well profiling
- Radioactive materials available
  - Basic technique for location of injection zones and channels

Quantitative Injection Profiling
- Area technique (PROBLEM)
- Area under GR curve indicates fraction of initial flow remaining

- **Velocity Shot Technique (PROBLEM)**
  - Selection of positions for velocity shot tests
  - Computation of volumetric flow rate

**Distributed Temperature Sensing (DTS)**
- What DTS is and how it works--non-intrusive temperature logs
- How the fiber optic line is set up in a well
- Quality/resolution issues
- Applications and examples

- **Distributed Acoustic Sensing (DAS)**
  - Full spectrum noise observation
  - Spectral noise logging to determine flow source and character

**PLATO Software Demonstration** (This may be optional with class participants)

**Course Instructor:**
James Smolen, Ph.D.