CASED HOLE AND PRODUCTION LOG EVALUATION

Course Objective:

This program is a comprehensive and up-to-date course covering the new and traditional wireline diagnostic techniques for surveillance of cased wells. Dr. Smolen's 1996 book, **Cased Hole and Production Log Evaluation**, plus a loose-leaf workbook, are provided to participants of this program. Note that class problems **(PROBLEMS),** movies **(MOVIES),** and guest lecturers **(GUEST)** have been highlighted. Numerous log examples for class discussion are also presented throughout the course.

Who Should Attend:

Reservoir and production engineers and geologists, petrophysicists, log analysts and others involved in well surveillance, maximizing recovery, identifying production problems, planning workover operations, and utilizing production information in reservoir studies. This course is also well suited for Cased Hole sales engineers.

Course Instructor:

Dr. James Smolen is the President and Independent Consultant provides training and consulting services to major service and operating companies in the area of cased hole and production well logging, both domestically and internationally. Consulting operations include production log evaluation services and special projects.

Course Agenda

DAY 1

M1 - **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

M2 - **Logging horizontal/highly deviated wells**
- Pump down systems
- Coiled tubing conveyance
- Tractoring devices

- **Downhole logging environment**

M3 - **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

A1 - **Pulsed Neutron Capture (PNC) Logs**
- Principles of neutron energy, gamma ray emissions, and capture
- Basic formation model
- Ideal log response **(PROBLEM)**

A2 - **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

A3 - **Development of the capture technique and log presentation**
- Major service company equipment development
- Primary and secondary log measurements

DAY 2

M1 - **Computation of saturations--clean and shaley zones (PROBLEM)**
- Dual water model overview
- Miscellaneous applications of PNC tools
  - Residual Oil Saturation, ROS, by log-inject-log technique

M2 - **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)**

M3 **- 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

A1 **- Carbon-Oxygen Measurements (continued)**
- Log presentations (BV, ratios, Ca/Si-C/O overlay, C/O envelope **(PROBLEM**))
- New tools (RST, RPM, RMT)
- Determination of saturation and holdup for the RST-B **(PROBLEM**

A2 **- Through-Casing Resistivity**
- Tool Theory
- Stationary measurements

- Formation Testing Through Casing
- Testing using perforations
- Plugging holes after testing (CHDT)

- Gas-View/Baker Atlas
- An enhanced Atlas RPM based technique for detecting gas

A3 **- 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

M1 **- 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

M2 - **Pad type bond logs, Atlas SBT**
- Configuration and operation
- Log presentation

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

M3 **- 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

A1 **- 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

A2 **- 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)**

A3 **- 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**
  - Shift proportional to metal remaining

DAY 4

M1 **- 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

M2 **- Interpretation of Spinner Logs for Bulk Production Profile**
- **Multipass plot technique (PROBLEM)**
- Interpretation when only down runs are available

M3 **- Two pass overlay technique (PROBLEM)**

- Flow profile correction factor
- Compute bulk production profile **(PROBLEM)**

A1 **- Fluid Identification Devices for Multiphase Flow**
- Holdup vs. cut
- Bulk fluid density
    - Pressure differential tools (Gradiomanommeter)
    - Nuclear fluid density, focused and unfocussed
        - Capacitance devices
- 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

A2 **- 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

A3 **- High Deviation Angle and Horizontal Multiphase Flow**
- Visualization of horizontal flow
    - Schlumberger Cambridge Research Center Video **(MOVIE)**
    - Schlumberger Flagship Tool String
        - Dual DEFT (Flowview Plus)
        - GHOST-Gas Holdup
        - 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)
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DAY 5

M1 **- 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

M2 **- 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

M3 **-Distributed Temperature Sensing (DTS) and Smart Well Logs**
- 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

- Other sensors for intelligent completions

A1 **Guest Speaker from Major Service Company** (Guest speakers will be invited to speak for one or two sessions at convenient times during the week)

A2 **PLATO Software Demonstration** (This may be optional with class participants)

PUBLICATIONS:

1. **Smolen, James J. and van der Spek, Alex, "Distributed Temperature Sensing—A DTS Primer for Oil & Gas Production" Unclassified, Shell International Exploration And Production B. V., The Hague, The Netherlands, 2003.**

2. **Smolen, James J., and Gysen, Michel, "PLATO User Manual" Shell International Exploration and Production B.V., The Hague, The Netherlands, and Interpretive Software Products, Inc., Houston, Texas, 2000.**

3. **Whittaker, J.L., Golich, G.M., and Smolen, J.J., "Diagnosing Horizontal Well Production in the Belridge Field with Downhole Video and Production Logs" SPE Paper 38295, 1997 SPE Western Regional Meeting, Long Beach, June 1997.**

4. **Smolen, James J., "Cased Hole and Production Log Evaluation" PennWell Publishing Comapany, Tulsa, Oklahoma, 1996.**

5. **Smolen, James J., "Cased Hole Logging", IHRDC, Boston, MA, 1991.**

6. **Smolen, J. J., "Cased-Hole Logging: A Perspective", The Log Analyst, March-April, 1987.**

7. **Smolen, James J. and Lazor, Fred, "Acoustic Cement Bond Log" Dresser Atlas, Houston, Texas, 1983.**

8. **Anderson, R.A., Smolen, J.J., Laverdiere, Luc, and Davis, J.A.,**

"A Production Logging Tool With Simultaneous Measurements" JPT, February 1980 (Also SPE Paper 7447).

9. Smolen, J.J. and Litsey, L.R., "Formation Evaluation Using Wireline Formation Tester Pressure Data" JPT, January 1979 (Also Paper SPE 6822).

10. Smolen, James J., "RFT Pressure Interpretation", Document C-12003, Schlumberger Well Services, Inc., Houston, Texas, 1977.

11. Anderson, R. A. and Smolen, James J., "Methods for Determining Velocities and Flow Rates of Fluids Flowing in Well Bore" United States Patent 3,954,006, May 1976.

12. Smolen, James J., "PAT Provisory Interpretation Guidelines" Document C-12013, Schlumberger Well Services, Houston, Texas, 1976.

13. Leach, B.C., Jameson, J.B., Smolen, J.J., and Nicolas, Y., "The Full Bore Flowmeter" 49th Annual SPE Meeting, Houston, Texas, Oct. 1974 (Also Paper SPE 5089).

14. Oppenheim, A.K., Smolen, J.J., Kwak, D. and Urtiew, P.A., "On The Dynamics Of Shock Intersections" Fifth Symposium (International) on Detonation, Pasadena, California, August 1970.

15. Oppenheim, A.K., Smolen, J.J., and Zajak, L.J., "Vector Polar Method for the Analysis of Wave Intersections" Combustion and Flame, February, 1968.