Reducing Uncertainty in Well Intervention and Workover

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X-rays and Well Intervention

- Lead impression block (ambiguous results)
- Video camera (well cleaning)
- Ultrasonic imaging (ambiguous results, well cleaning)
Quick, reliable visualization & quantification

Understand problem

Enact appropriate solution

Complete intervention efficiently

Downhole X-ray Diagnostics break the cycle
• Intro to X-ray imaging in a well
• Performing downhole X-ray diagnostics
• Case studies and examples
Transmission imaging not feasible in well, so use backscatter imaging.
Most backscattered radiation from fluid => low SNR

Radiation proportional to amount of fluid

Use scattering from fluid => turn “noise” into “signal”

Obtain distance to object from amount of scattering
Depth map images =>
Dark = far, Light = close
Render in 3D

• Dimensionally accurate
• Resolve small features
• High-precision measurements
• Near real time imaging
The X-ray Advantage

• X-rays penetrate a variety of materials
  - Oil
  - Brine
  - Oil/water mixtures
  - Gas
  - Fluids with suspended particulates
  - Cement
  - Sediments

• Real time, no well preparation necessary

• Intrinsically safe electronic X-ray sources =>
  no radioactive materials, no residual radiation
Performing X-ray Diagnostics

Fluid calibration image (~20 minutes)

Target image (~5-20 minutes)

Image processing (seconds)
Flapper Valve Issues

- North Sea - Presumed stuck flapper on TRDHSV
- X-ray images at multiple depths identified and measured flapper mobile over range of openings
- Outcome: Wireline insert DHSV successfully installed; well is back in operation; saved significant time, expense, and risk
Collapsed/Burst Casing

- Permian Basin – Plugging well, unknown obstruction, suspected collapsed casing
- LIB run gave no useful information
- X-ray images clearly showed casing damage, provide diameter, showed burst section and debris/formation entry
- Outcome: Approval to plug well at shallower depth than planned
Parted Casing

- Permian Basin – Plugging well, unknown obstruction, suspected parted CSG
- VR90 images showed top of parted casing, residual cement
- Outcome: Approval to plug well at shallower depth than planned
• Permian Basin – guidance on fishing pulled-off tubing
• X-ray images showed tubing top bent over, shredded
• Outcome: Suggested fishing with spiral grapple; fished successfully first attempt
Summary

- New X-ray imaging technique is quick and accurate
  - X-rays penetrate most common well fluids => no need to clean well
  - Novel fluid-based technique gives dimensionally-accurate 2D images and 3D reconstructions
  - Near real-time data acquisition and processing => useful as decision-making tool

- Quick, reliable downhole imaging used as diagnostic tool to provide information about conditions in well => reduced uncertainty and improved efficiency during well interventions and workover
Thank you!

Questions?
Inspect Cut Tubing

- North American land – Inspect cut and stuck tubing left in well
- Camera run with extensive circulation failed
- Locate tubing top, measure size
- X-ray images show tubing centered in hole, inner and outer diameters reduced from 2.44” to 1.85” and 2.875” to 2.68” respectively

- Outcome: Pending
Reactivate Old Well - Unknown Fish

- Netherlands, onshore – Unknown obstruction in old well
- Multiple camera runs failed
- Identify fish, obtain information about shape, size, position
- X-ray images clearly identified fish, precisely measured position and dimensions
- Outcome: Pending
Fishing Coiled Tubing Disconnect

- Netherlands, onshore – verify size, integrity of CT disconnect
- X-ray images gave ID and OD to within ± 1 mm, revealed debris inside disconnect
- Outcome: correct fishing method chosen and fished successfully first attempt
Pulling a Plug

- North Sea – Unable to pull plug
- Multiple inconclusive LIB runs
- X-ray images at several locations confirmed fish integrity, position; identified debris inside fish
- Outcome: Cleaned out plug, successfully latched and pulled plug on next attempt
Cut Tubing with Debris

- Evaluative case study – unable to fish cut tubing
- High-precision X-ray images show tubing flared on top and capillary lying across tubing top
- Outcome: Properly prepare fish, choose proper fishing tools, fish more successfully
Debris on a Fishing Profile

- Evaluative case study – unable to fish hardware with internal profile
- 3D reconstruction from X-ray imaging shows tube over and across fishing profile
- Outcome: Properly prepare fish, save time fishing blindly
Depth from Intensity

Photon flux onto detector for steel plate and water

![Graph showing photon flux onto detector for steel plate and water.](image)

Detected count rate versus depth

![Graph showing detected count rate versus depth.](image)

Ref: Spannuth et al. SPE 170706
## Tool Specifications

### VR90 Specifications

- **Pressure rating:** 20kpsi | 1380bar
- **Temperature rating:** 212°F | 100°C
- **Outer diameter:** 3-5/8 in | 92mm
- **Min restriction:** 4 in | 101mm
- **Length w/o X-overs:** 27ft 6in | 8.37m
- **Weight in air:** 520lbs | 235kg
- **Integrated gamma ray/CCL
- **Works with cables of up to 15km in length
- **Compatible with tractors, strokers & CT**

### VR90s Specifications

- **Pressure rating:** 13kpsi | 900bar
- **Temperature rating:** 257°F | 125°C
- **Outer diameter:** 3-3/8 in | 86mm
- **H₂S rating:** NACE compliant
- **Precise positioning with integrated anchor-stroker (52cm range)
- **Wide-angle field-of-view coming soon**