Advancing Reservoir Performance

Coiled Tubing Telemetry System Improvements with Real-Time Tension, Compression, and Torque Data Monitoring

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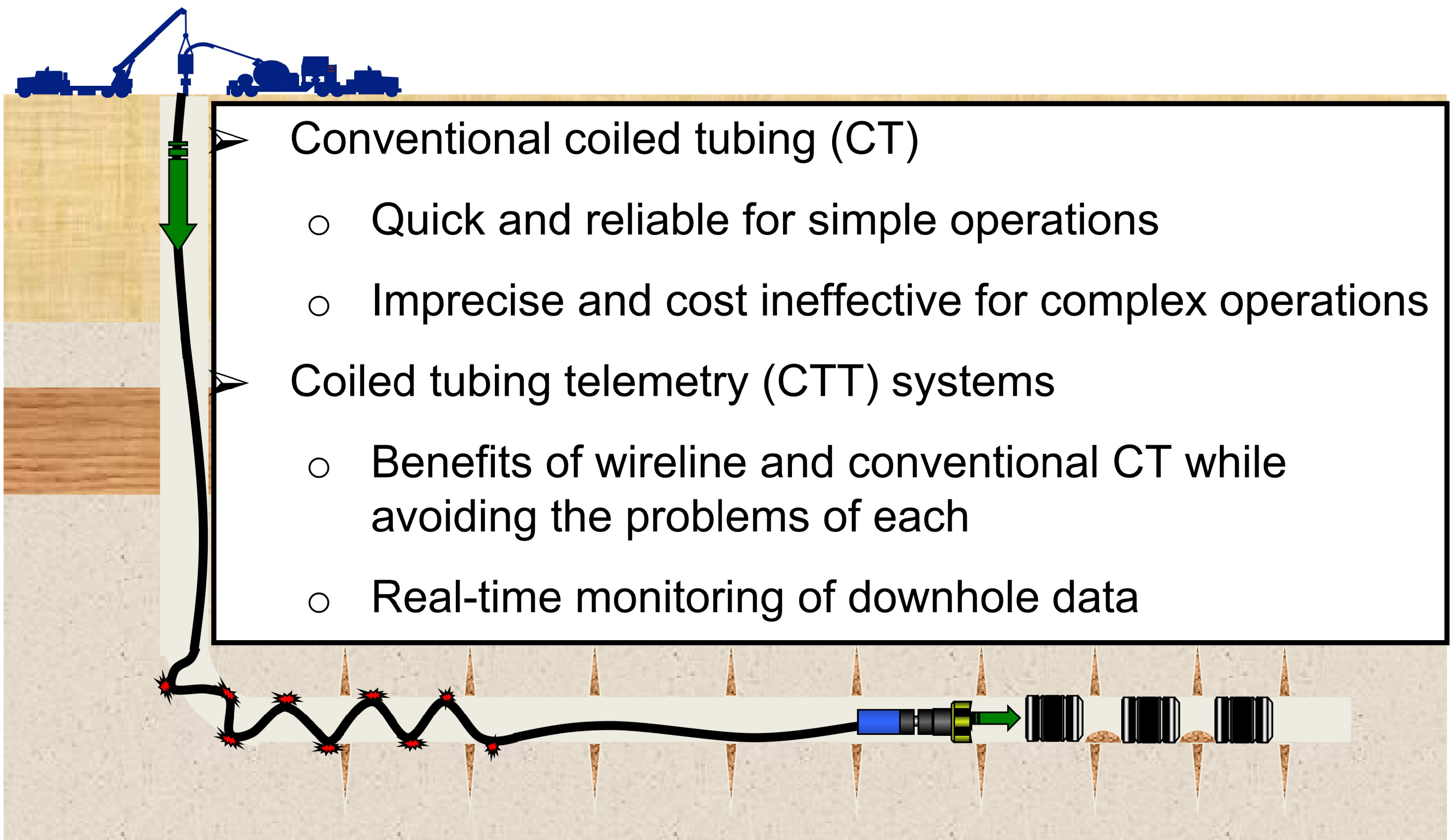
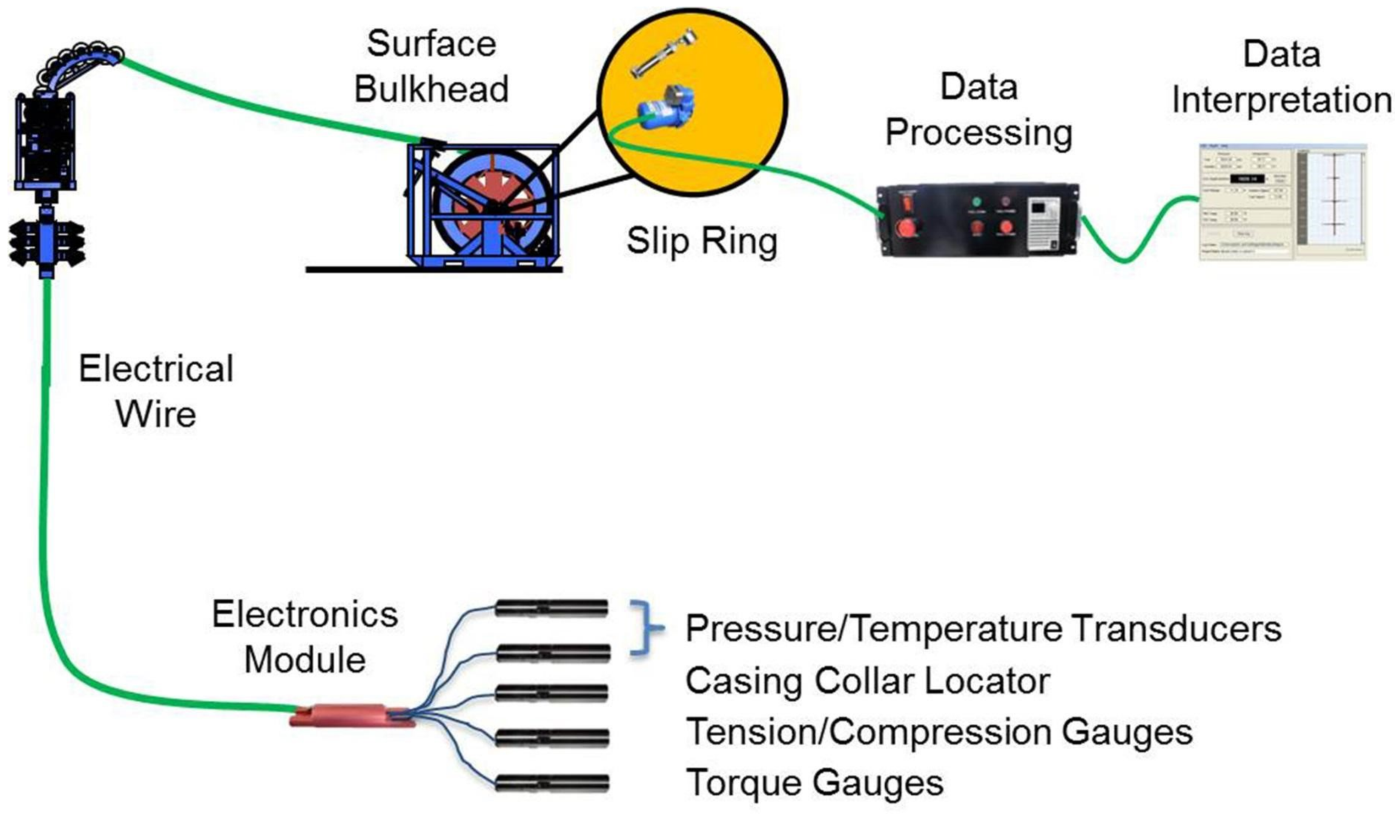
BAKER HUGHES

The Problem to be Solved



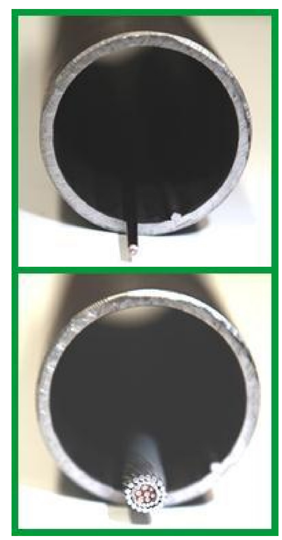
- Conventional coiled tubing (CT)
  - Quick and reliable for simple operations
  - Imprecise and cost ineffective for complex operations
- Coiled tubing telemetry (CTT) systems
  - Benefits of wireline and conventional CT while avoiding the problems of each
  - Real-time monitoring of downhole data

CTT System Architecture

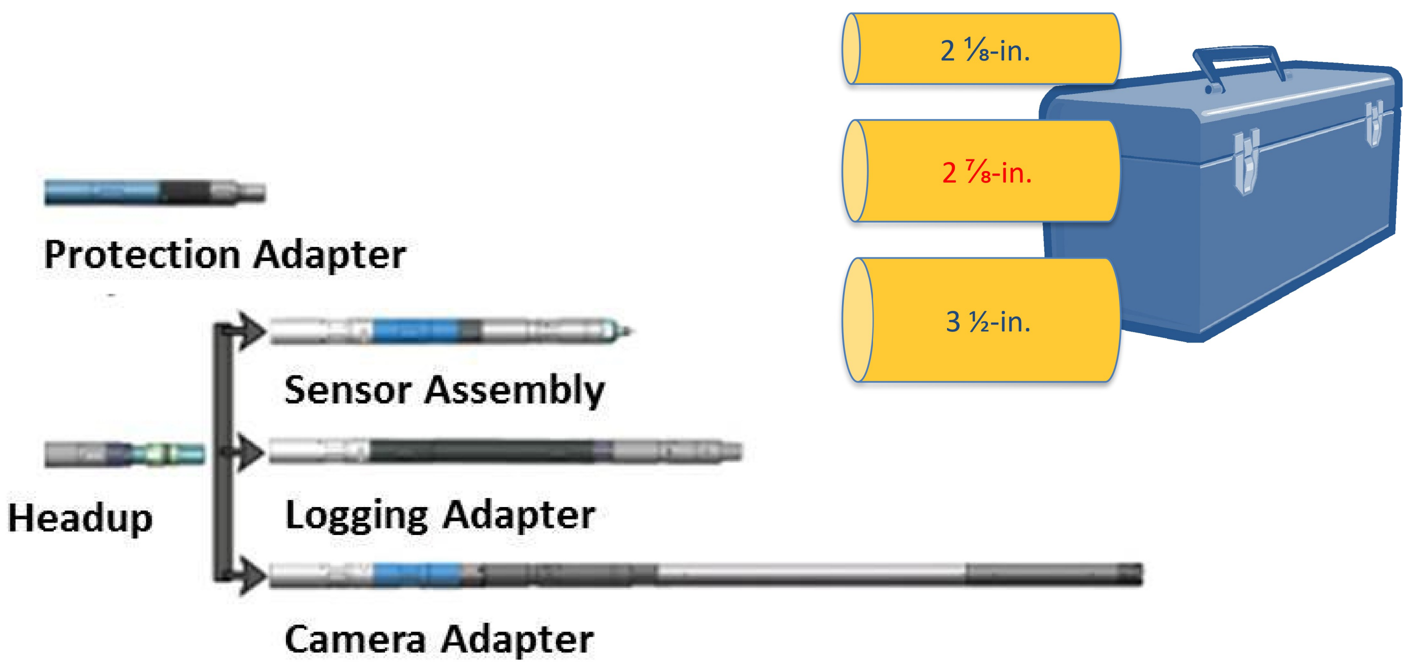


CTT Wire

- 1/8-in. outside diameter (OD) corrosion resistant alloy tube
- Housing insulated electrical conductor
- Non-intrusive
- Passage of activation balls
- Extremely quick head up (<30 minutes)
- Compatible with common oilfield fluids and slurries
- Minimal effect on flow rates, friction pressures
- Minimal weight (about one tenth of braided cable)

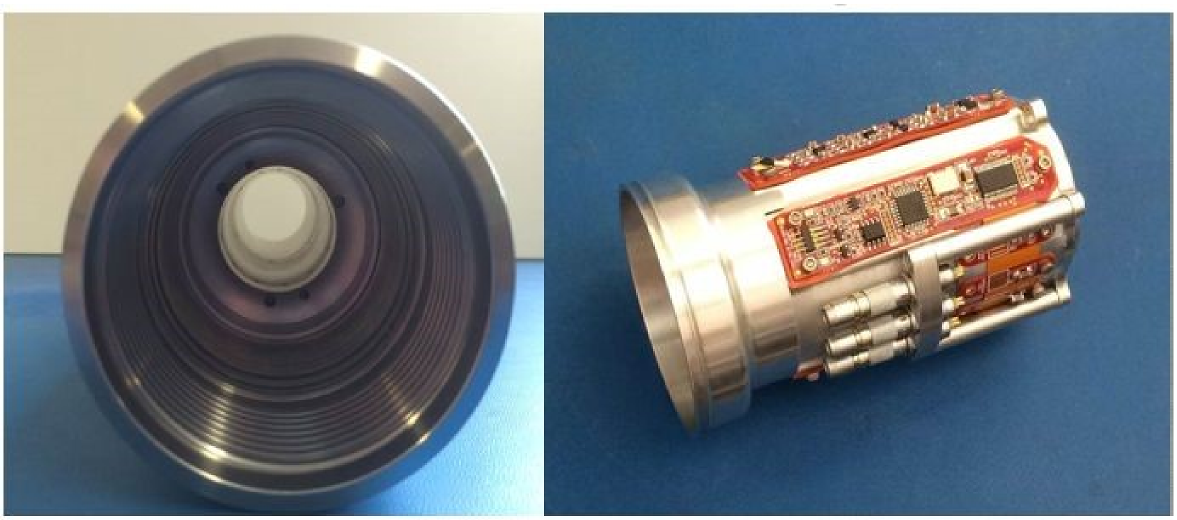


CTT Tools



Protection Adapter
Headup
Sensor Assembly
Logging Adapter
Camera Adapter
2 ⅛-in.
2 ⅞-in.
3 ½-in.

Tension, Compression, and Torque (TCT) Assembly



TCT Electronics Module

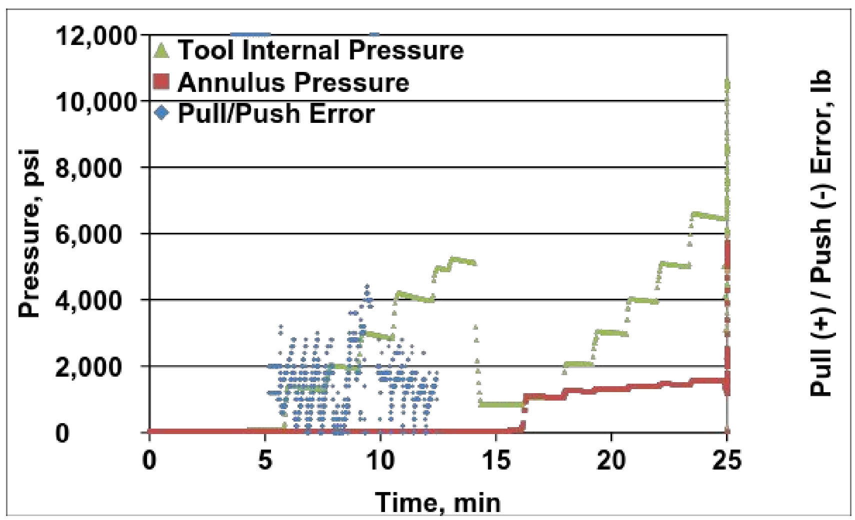
- Uses pressure/temperature transducers for compensation
- Calibrated for
  - +/- 30,000 lb. axial forces
  - 1,500 ft-lb torque (right hand)
- Design challenges
  - Low signal to noise ratio
  - Printed circuit boards installed in small space
  - Inside fluid flow path

TCT Assembly Laboratory Testing (1)

- ➢Tested sensor response in laboratory to external axial and torsional applied loads
- ➢Testing procedure
  - Known force/torque was applied in different steps and compared to the force/torque indicated by the TCT sensors
- ➢Tests done at atmospheric conditions (ambient pressure and temperature) and expected downhole values

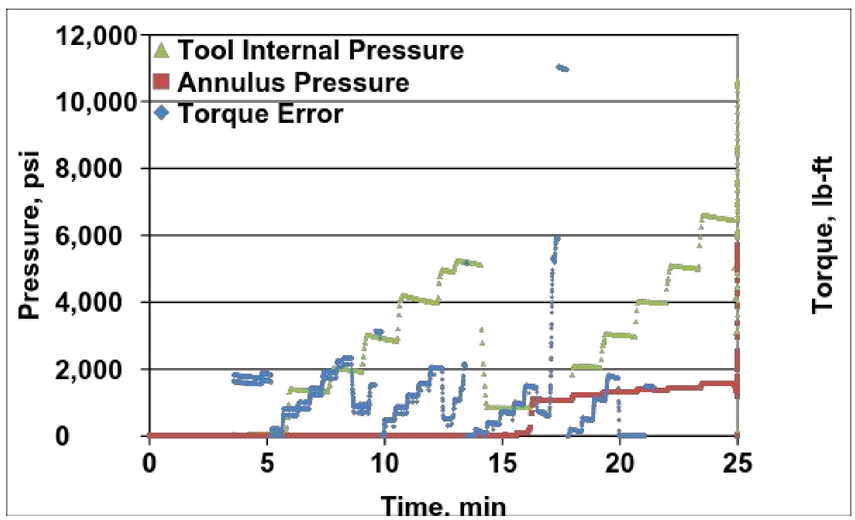
TCT Assembly Laboratory Testing (2)

- Applied/measured compression (-) and tension (+) force errors for annulus pressure between 0 and 6,000 psi
- High-load maximum tension/compression errors in the order of 100 lb
- Low-load maximum pulling/pushing errors in the order of 30 lb

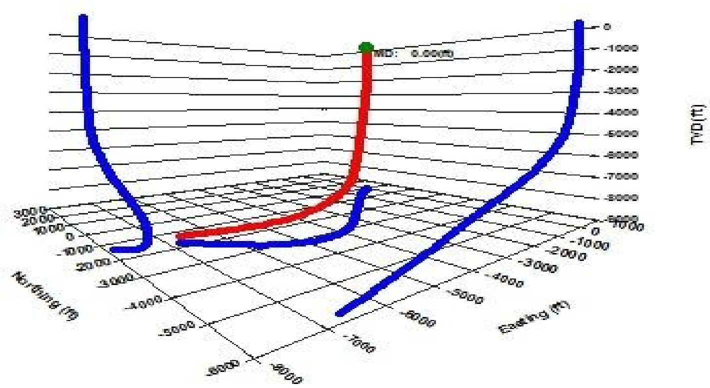


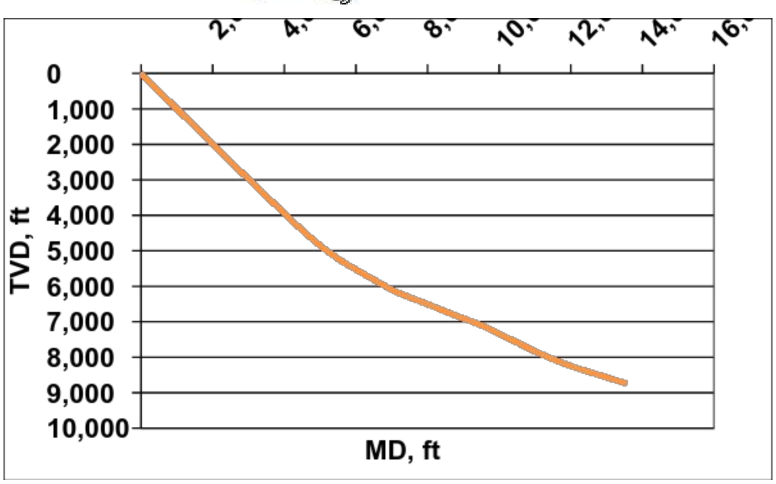
TCT Assembly Laboratory Testing (3)

- Applied and measured torque errors for annulus pressure between 0 and 6,000 psi
- Maximum torque error was 26 lb-ft
- Temperature effects are strongest and need to be compensated
- A temperature change of 1˚C gives an apparent strain of 30 lb



Case History – Well Details



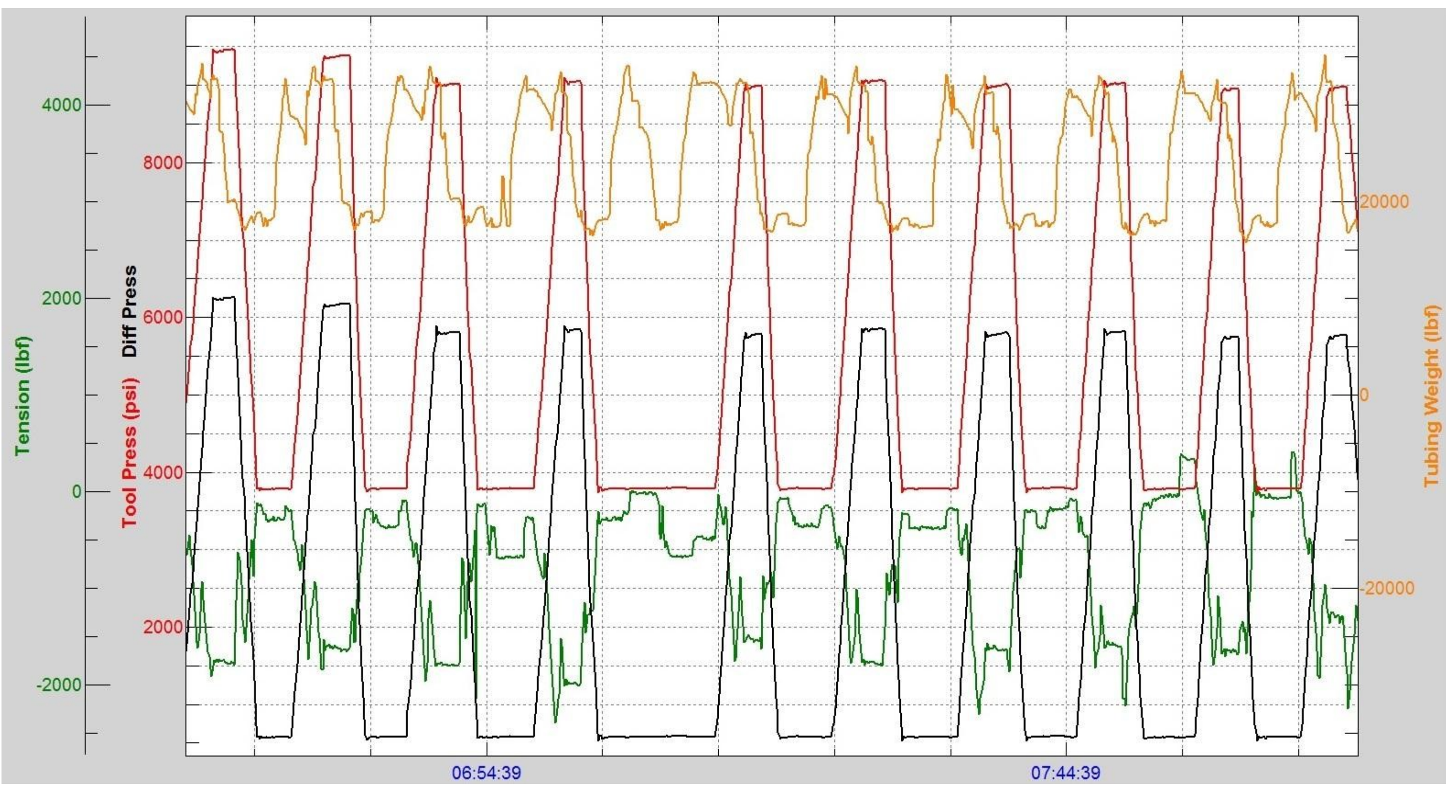


- ➢ Offshore well in Caspian Sea
- ➢ Upper completion mainly 7-in. Cr13 and L-80 tubing
- ➢ Unconsolidated sandstone formation
- ➢ Uneven gravel packing in several sections allowed incoming sand to damage the screens and began filling the wellbore
- ➢ Permanently installed distributed acoustics sensing (DAS) fiber indicated several sand entry points along the wellbore

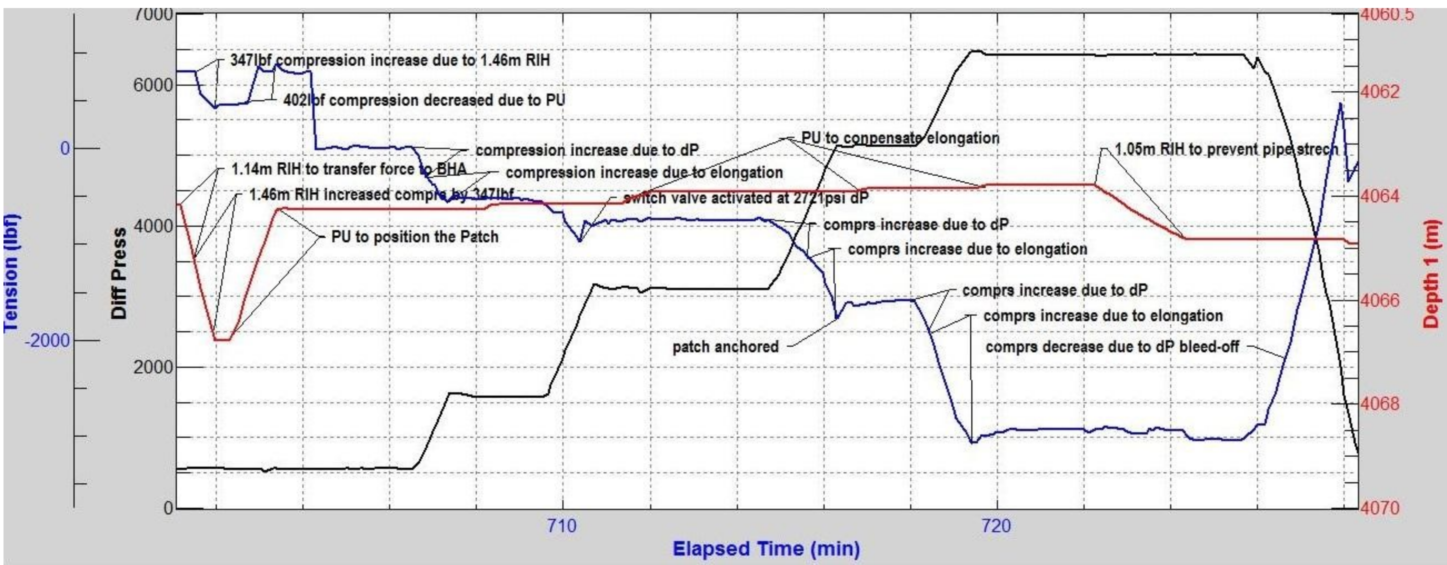
Case History – Planned Objectives

- Conduct a concentric CT cleanout to remove sand from the wellbore and reach TD
- Set a bridge plug with the CTT system at the depth of 13,481 ft MD
- Set six 44.3 ft-long 3-in. OD expandable steel patches over two different intervals
  - Between 13,173 and 13,327 ft MD (four patches)
  - Between 12,710 and 12,787 ft MD (two patches)

Case History – Snapshot of Typical Setting Steps



Case History – TCT Assembly Output

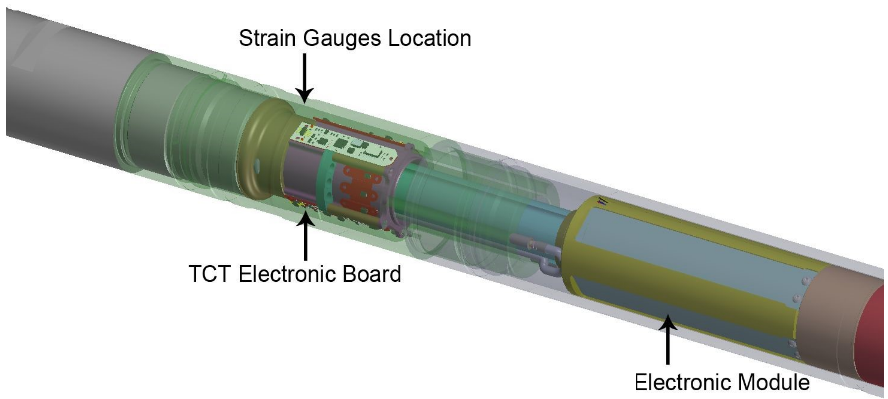


Case History - Outcome

- Well was cleaned out up to 13,481 ft MD (tagged) recovering a total of 452 lb of sand in one run
- A high-pressure, high-temperature (HPHT) sand shutoff plug was successfully installed at 13,481ft MD with the CCT system with no downtime or non-conformance recorded during the bridge plug setting
- A 3.75-in. test packer was run in hole to understand the downhole behavior of the CT and TCT assembly
- Six expandable steel patches were placed at the pre-determined depths (each required approximately 25 steps)
- Total time to perform the entire operation was 286.25 hours, five days ahead of the operator’s estimate

Operational Benefits of the TCT Assembly

- Milling optimization
- Fishing time reduction
- Extended-reach capabilities enhancement
- Cleanout execution enhancement
- Actuation and position verification



Conclusions

- TCT assembly is modular and could be easily installed and uninstalled from the main sensor assembly of the CTT system
- An extensive laboratory testing regime has been performed at atmospheric and downhole conditions resulting in:
    - Improved pressure compensation
    - New temperature compensation
- Reported results for a complex operation in an offshore well in Caspian Sea
    - Cleaned out using a concentric coiled tubing technology
    - Six expandable steel patches were installed
    - Overall, the TCT assembly reacted qualitatively as expected, with job completed in five days ahead of the operator’s estimate

Acknowledgements

CTRE/Baker Hughes Staff

Thank You / Questions