Advancing Reservoir Performance

Recent Advancements with a Unified Coiled Tubing Extended-Reach Technology



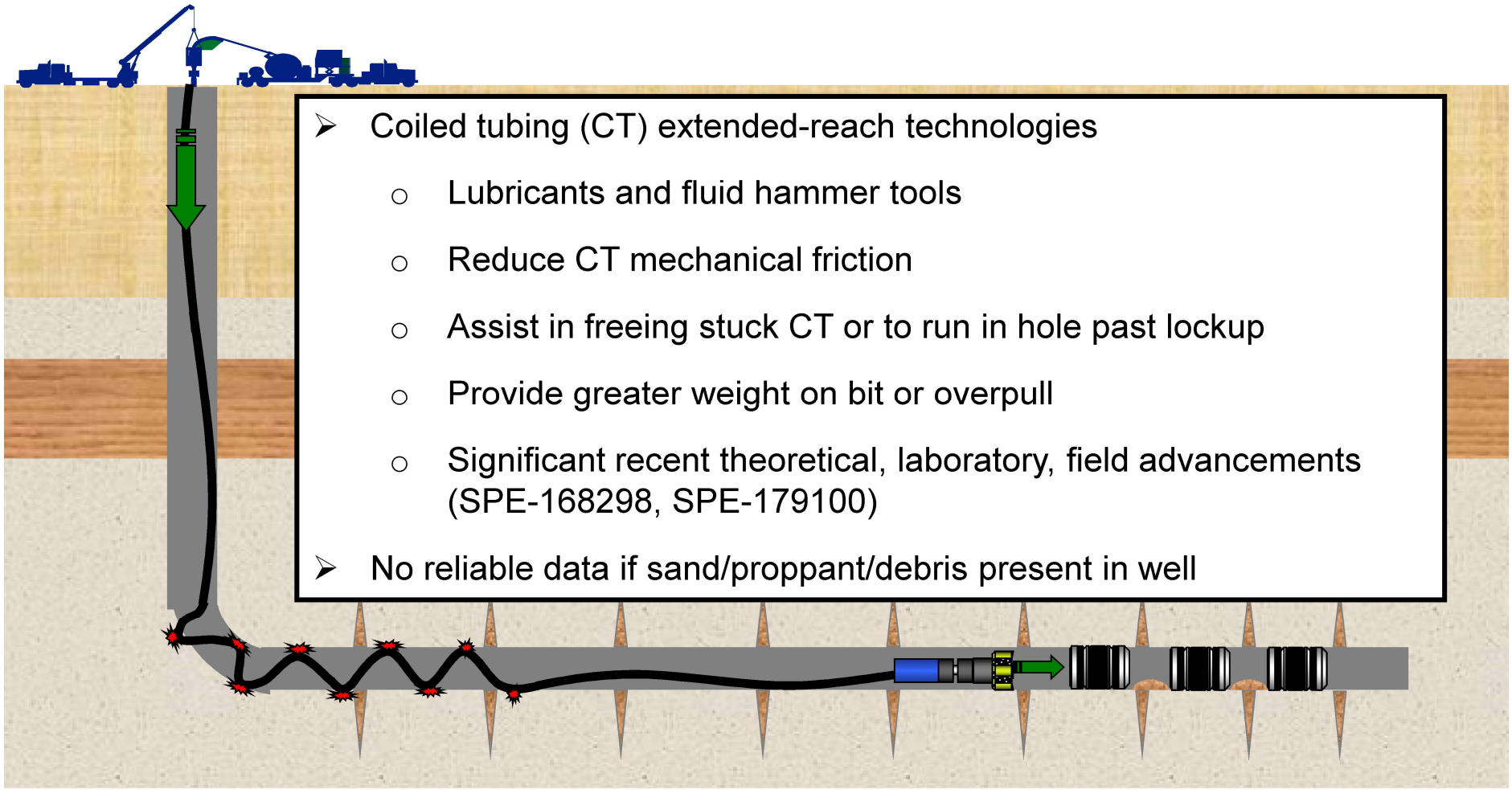
Silviu Livescu, Baker Hughes Coiled Tubing Research and Engineering (CTRE)

October 19, 2016

ICoTA Roundtable, Calgary, Canada

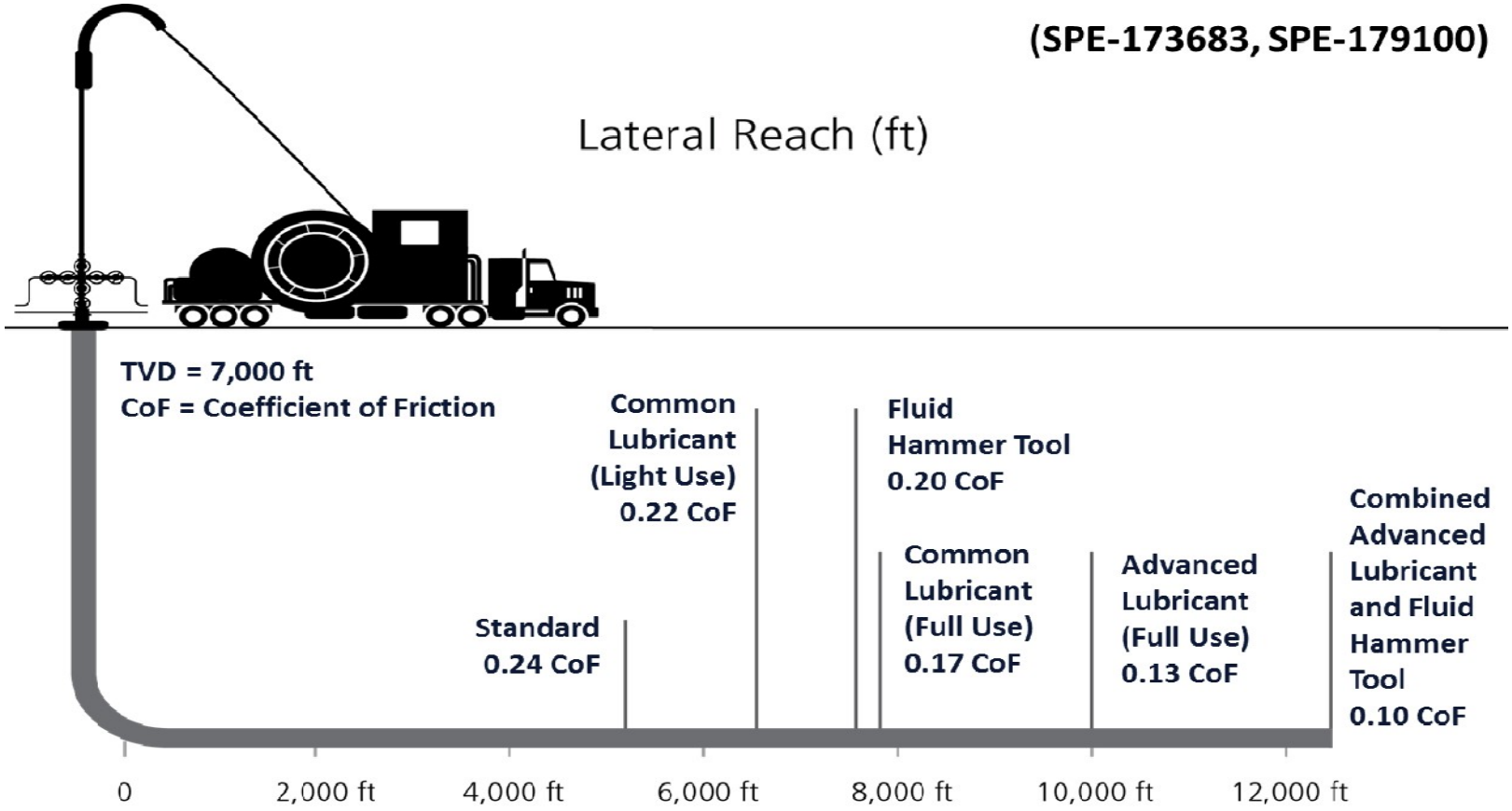
BAKER HUGHES

What Problem is Solved?



- Coiled tubing (CT) extended-reach technologies
  - Lubricants and fluid hammer tools
  - Reduce CT mechanical friction
  - Assist in freeing stuck CT or to run in hole past lockup
  - Provide greater weight on bit or overpull
  - Significant recent theoretical, laboratory, field advancements (SPE-168298, SPE-179100)
- No reliable data if sand/proppant/debris present in well

Recent CT Extended-Reach Advancements



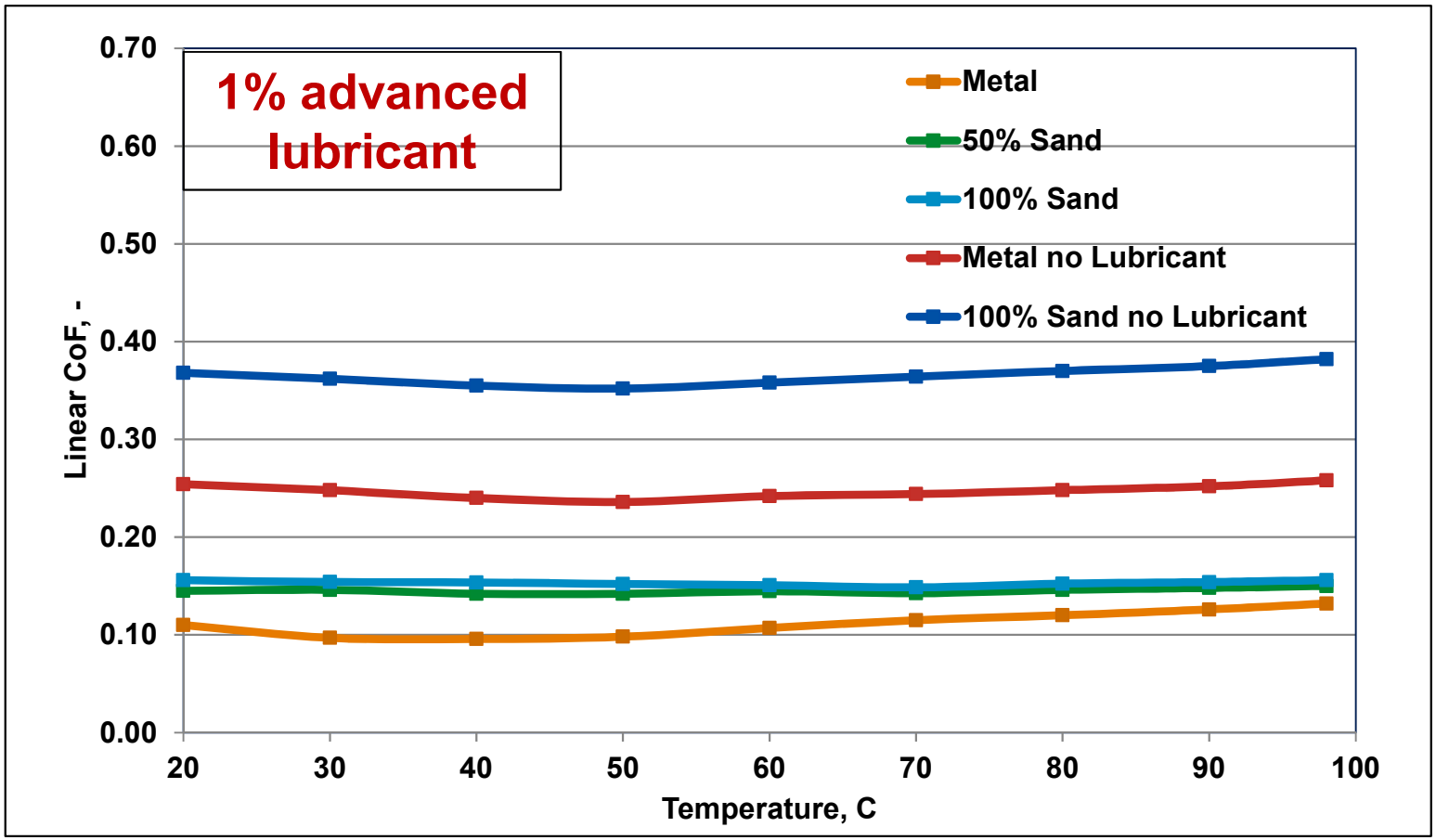
Note: Sample analysis 2" CT in 5½" horizontal well. Ability to transfer 500 lbf available weight on bit for each condition listed above.

Rotational and Linear Friction Tests vs. Field Data

Lubricant	Rotational CoF at 20°C	Linear CoF at 98°C	Field CoF
None	0.34	0.28	0.24 - 0.28
2% Lubricant 1	0.04	0.20	0.19 Mostly (0.17 Rarely) - 0.24
2% Lubricant 2	0.05	0.18	0.19 Mostly (0.17 Rarely) - 0.24
2% Advanced Lubricant	0.08	0.12	0.13 - 0.14

- 8 base fluids: tap water, fresh water, 2% KCl, seawater, produced water, 8% HCl, Diesel, mineral oil
- 20 lubricants (third-party and proprietary)
- 4 hydraulic friction reducers
- Well tubular metallurgy: P110 and Cr13 (multiple roughness values)
- Coiled tubing: 90, 100ksi conventional and Cr13
- SPE-168298, SPE-170635

Laboratory Testing – Advanced Lubricant on Sand Surfaces



0.36 CoF

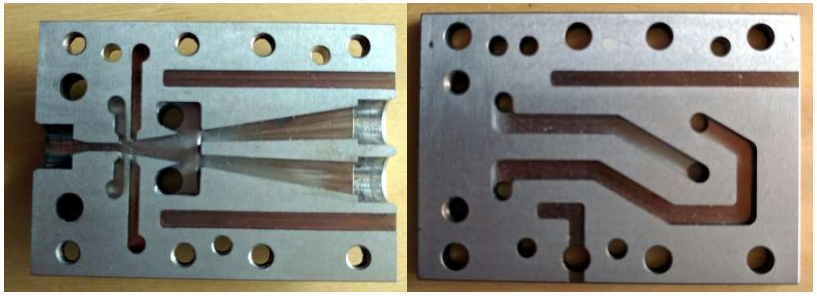
0.24 CoF

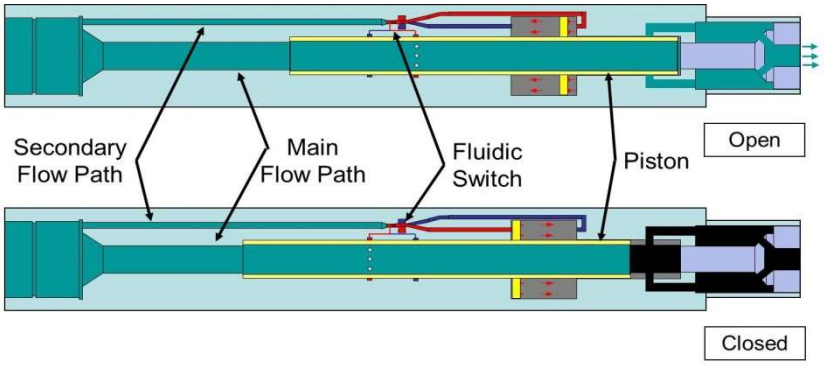
0.15 CoF

0.10 CoF

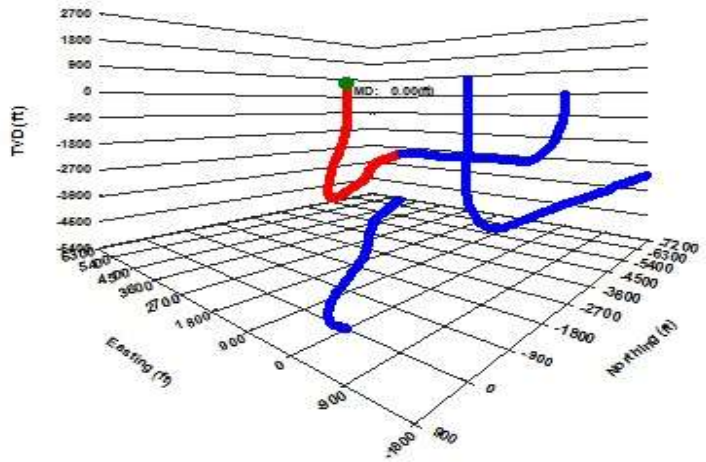
Fluid Hammer Tool

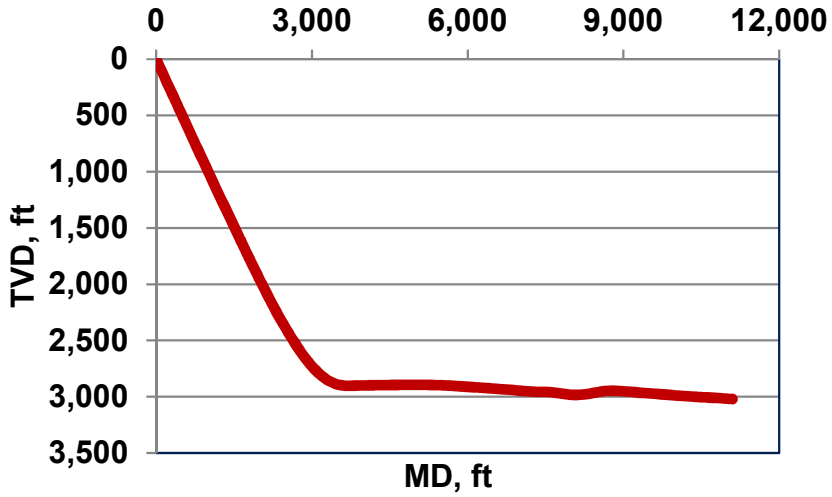
- Uses a fluidic switch based on Coandă effect (SPE-168297, SPE-179100)
- Recent mathematical model calculates apparent CoF and axial pulling force in pre-planning stage
- Field CoF reduced by 10-20% depending on job parameters (well trajectory, pumping rate, downhole pressure, CT size, etc.)
- Wellbore sand/proppant does not affect tool performance





Case History – Well Details

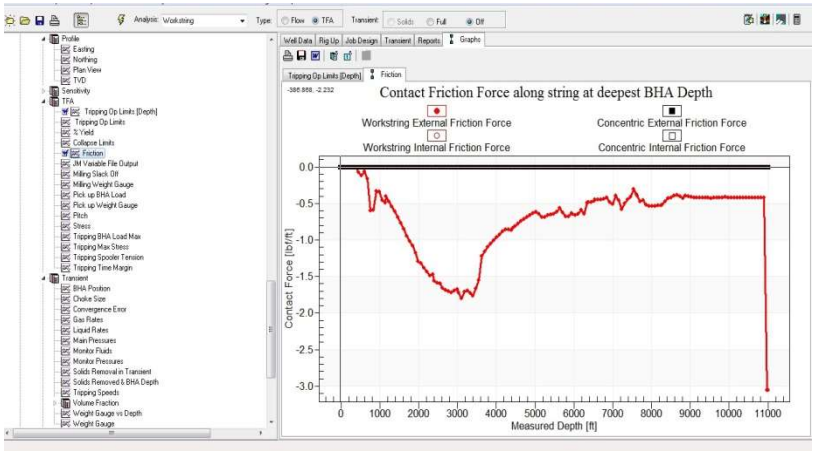




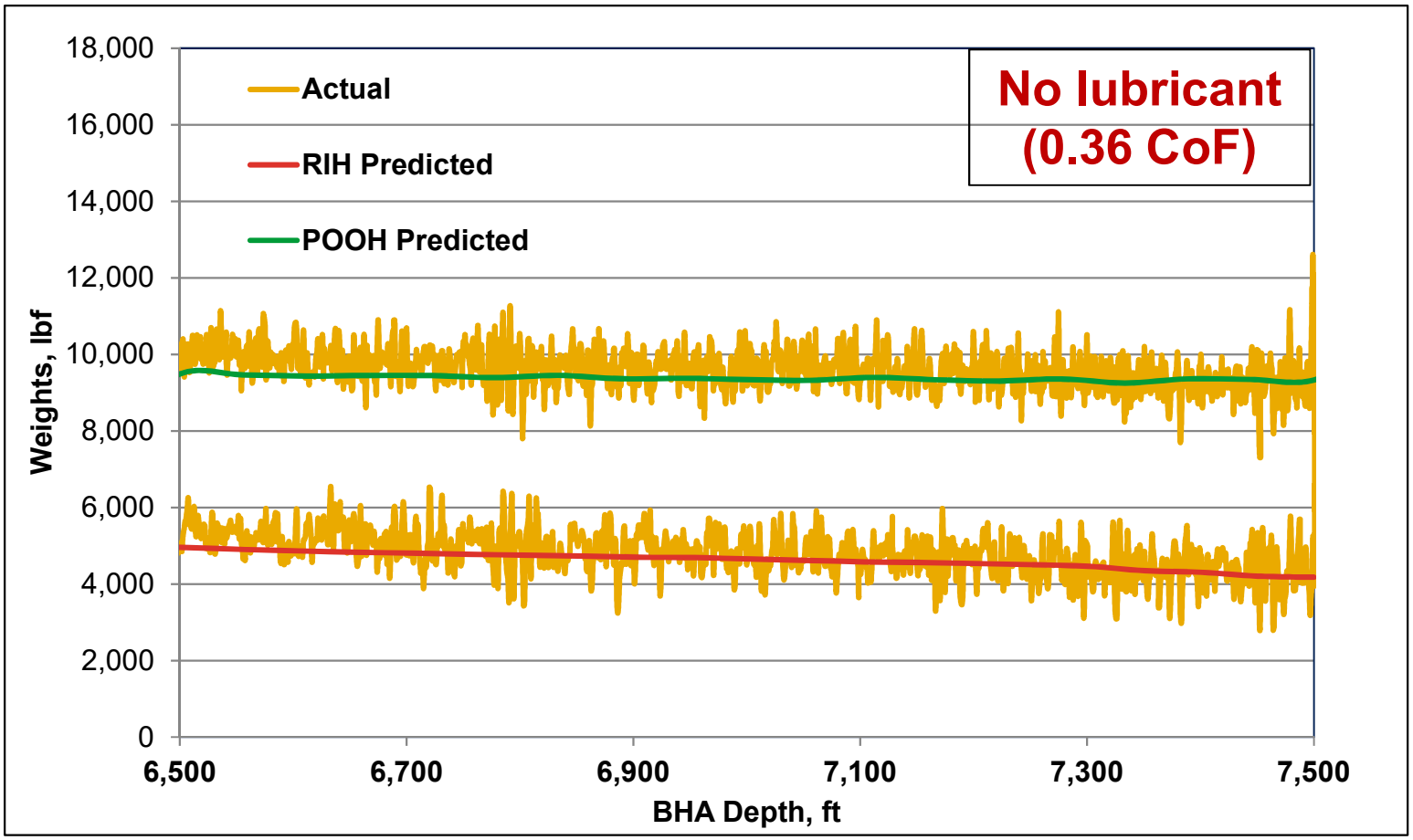
- ‘J shaped’ sand-screen-completed injector well in the North Sea with scale buildup
  - 11,030 ft MD
  - 7,454 ft lateral
  - 5 ½-in. tubing from surface to 6,340 ft
  - 6 ⅝-in. sand screen from 6,340 ft to MD
  - 1,245 psi and 96˚F (36˚C)
- No previous intervention in this well

Case History – Operation Details

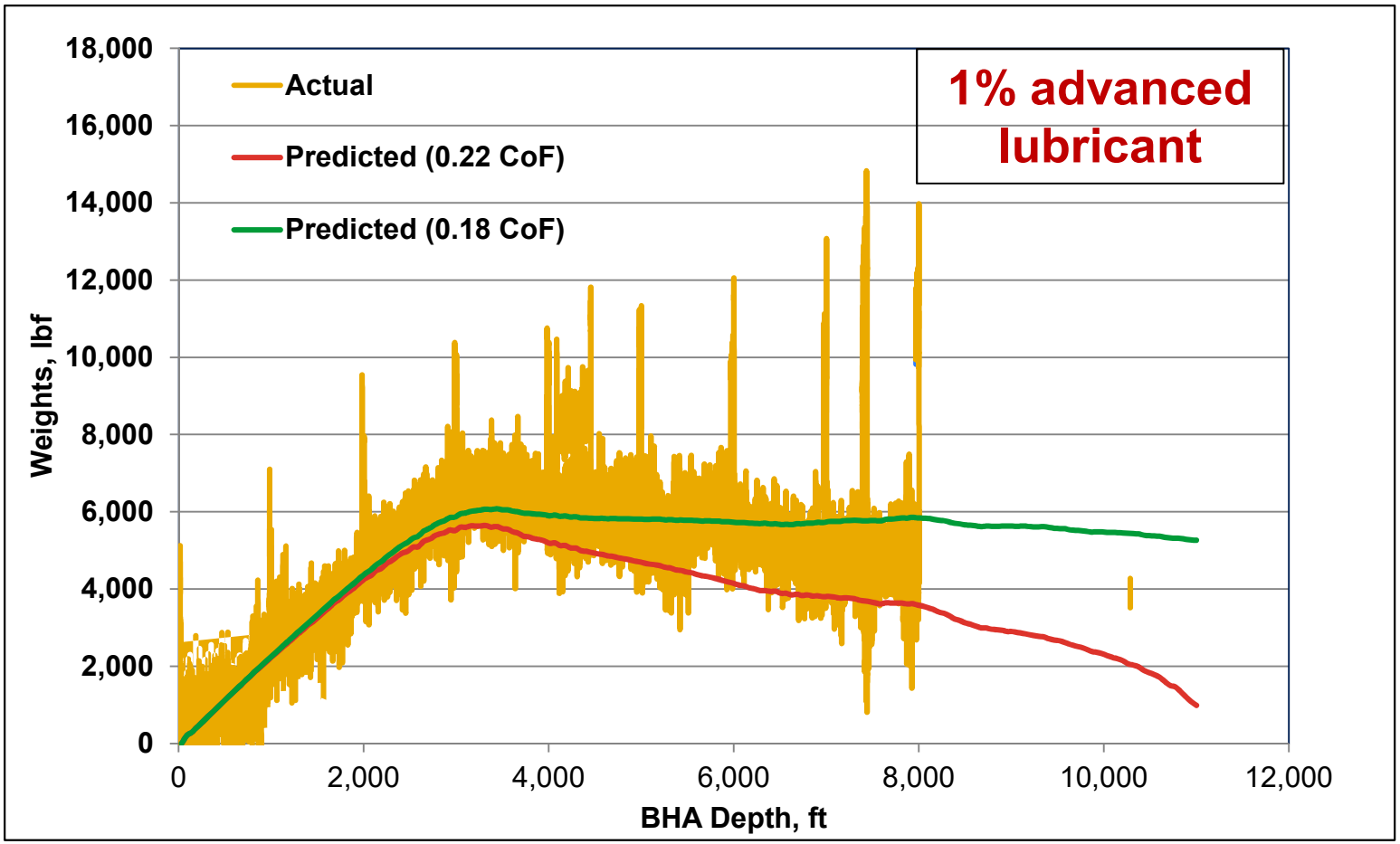
- 2-in. CT, 2 1/8-in. rotary jetting tool, 2 7/8-in. fluid hammer tool, and advanced lubricant
- Pre-job modeling
  - Lockup at 8,500 ft with default CoF of 0.36
  - 0.27 CoF (25% reduction) needed to reach MD
- Advanced lubricant was tested in laboratory for compatibility with acid
  - Live and spent acids



Case History – Actual and Predicted Weights (1)



Case History – Actual and Predicted Weights (2)



Case History – Outcome

- In first run, CoF reduced by 44%
  - CoF reduced from 0.36 to 0.20 (0.18-0.22)
  - 1% advanced lubricant pumped continuously
  - Fluid hammer tool not utilized
- In subsequent runs, advanced lubricant pumping schedule was adjusted
  - Advanced lubricant used only between 6,340 and 11,030 ft (corresponding to the sand screen)
  - Saved operator from pumping 220 gallons of lubricant
  - Eliminated an estimated six hours of rig time

Conclusions

- Laboratory testing of advanced lubricant on silica-sand-covered surfaces (50 and 100% covered) for temperatures between 20 and 98˚C
  - Mimics sand-filled wells or openholes
  - Default average CoF of 0.36 (no lubricant)
  - Average CoFs reduced to 0.15 (58% CoF reduction)
  - Temperature effect on CoF is much smaller when sand is present
- Field operation in a sand-screen-completed well
  - CoF reduced from 0.36 to 0.20 (44% CoF reduction)
  - Unified technology (lubricant and fluid hammer tool) reaching target depth
- Openhole operations to be performed in future

Acknowledgements

CTRE/Baker Hughes Staff

Thank You / Questions

Backup – CT Rotational Friction Testing

(www.ofite.com)

- Industry standard: rotational lubricity testers
- Testing at room temperature and atmospheric pressure
- Not adjustable contact surface roughness
- High contact pressure and rotational speed
  - Mimics drill collar forces
- Does not take into account CT downhole conditions
  - CT linear sliding and light contact pressure
  - CT/well tubular surface roughness

Backup – CT Specific Linear Friction Testing

- Directly calculates mechanical friction with ability to vary:
  - Temperature
  - Surface roughness
  - CT/casing samples
  - Fluid mixture

  - Constant pressure*
  - Constant speed*