Advancing Reservoir Performance

Challenging Industry's Understanding of How Lubricants Help Decreasing CT Size



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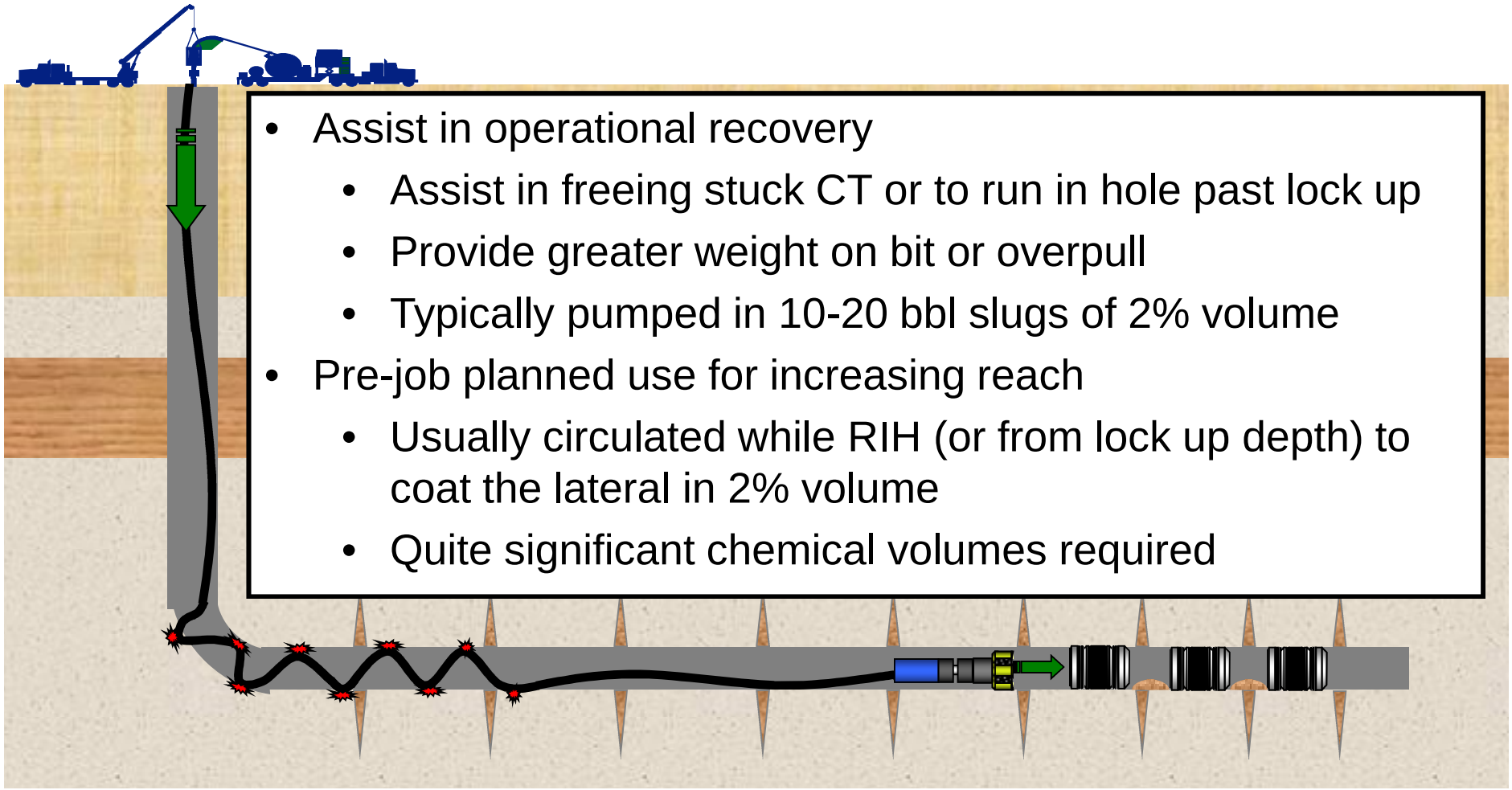
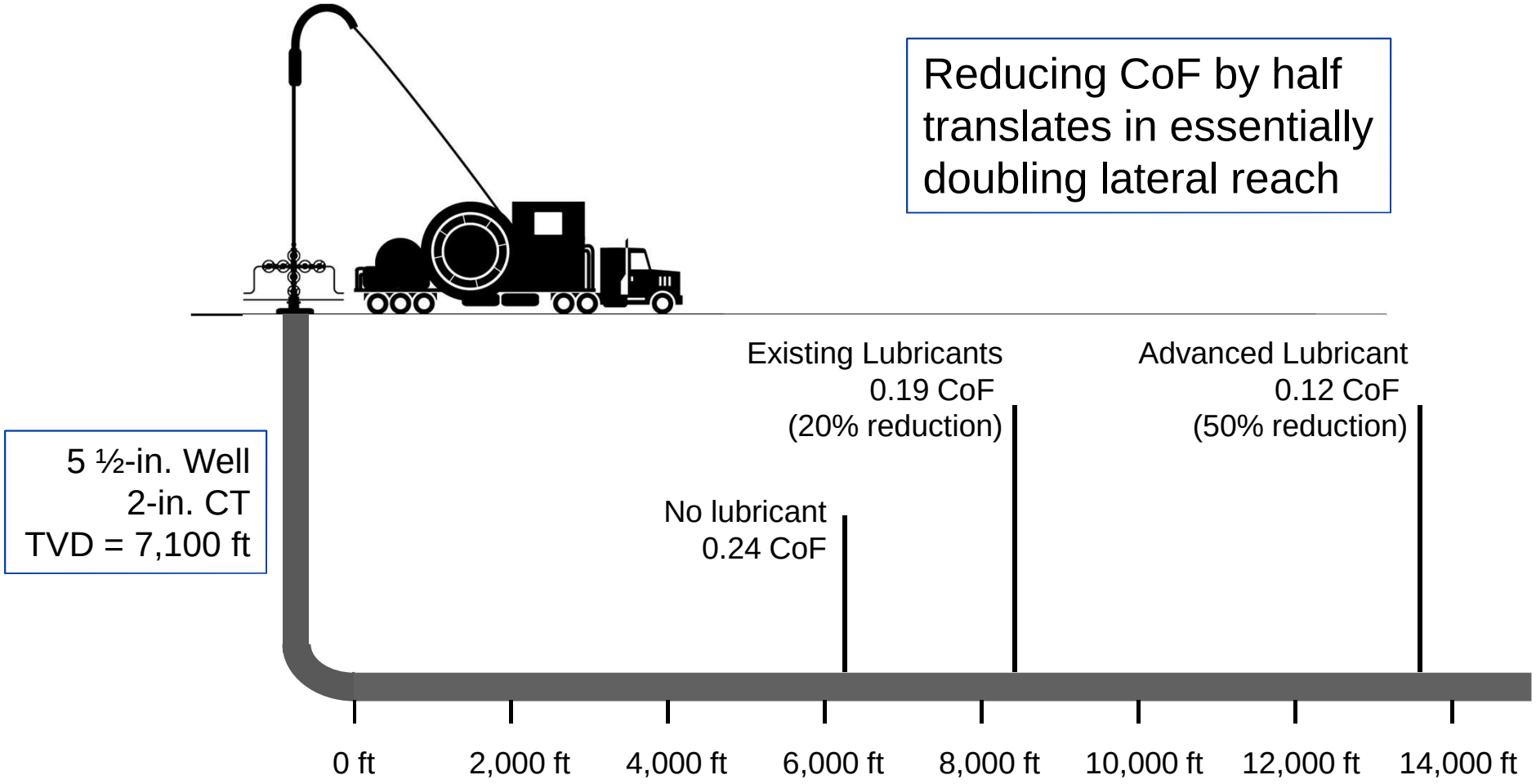
BAKER HUGHES

Why Are Lubricants Used in CT Operations?



- Assist in operational recovery
  - Assist in freeing stuck CT or to run in hole past lock up
  - Provide greater weight on bit or overpull
  - Typically pumped in 10-20 bbl slugs of 2% volume
- Pre-job planned use for increasing reach
  - Usually circulated while RIH (or from lock up depth) to coat the lateral in 2% volume
  - Quite significant chemical volumes required

Current Lubricant Performance for 5 ½-in. Well / 2-in. CT



Current CT Rotational Friction Testing

- Industry standard: rotational lubricity testers
- Testing at room temperature and atmospheric pressure
- 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

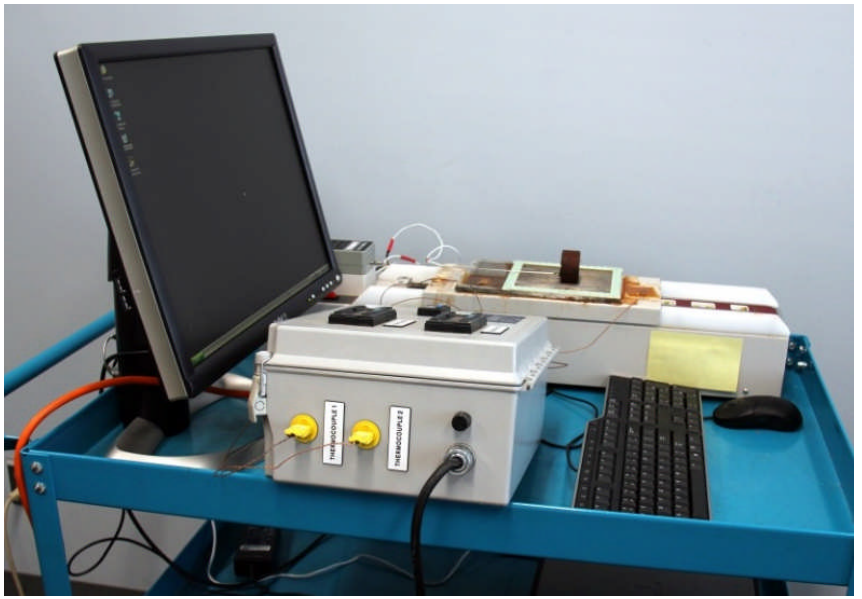
(www.ofite.com)

Lubricant	Rotational CoF at 20ºC	Rotational Friction Reduction
None	0.34	-
2% Existing Lubricant 1	0.04	88%
2% Existing Lubricant 2	0.05	85%
2% Advanced Lubricant	0.08	76%

Comparative CoF values for current lubricants in 2% KCl Brine and 0.1% Hydraulic Friction Reducer

First in Industry CT Linear Friction Testing

- CT friction depends mostly on
  - Temperature
  - Contact surface roughness
  - Full blend of downhole fluids
- CT friction depends slightly on
  - Pressure
  - Speed
  - Load
- CT friction does not depend on
  - Moving direction
  - CT and casing sizes



Linear Friction Testing Variables

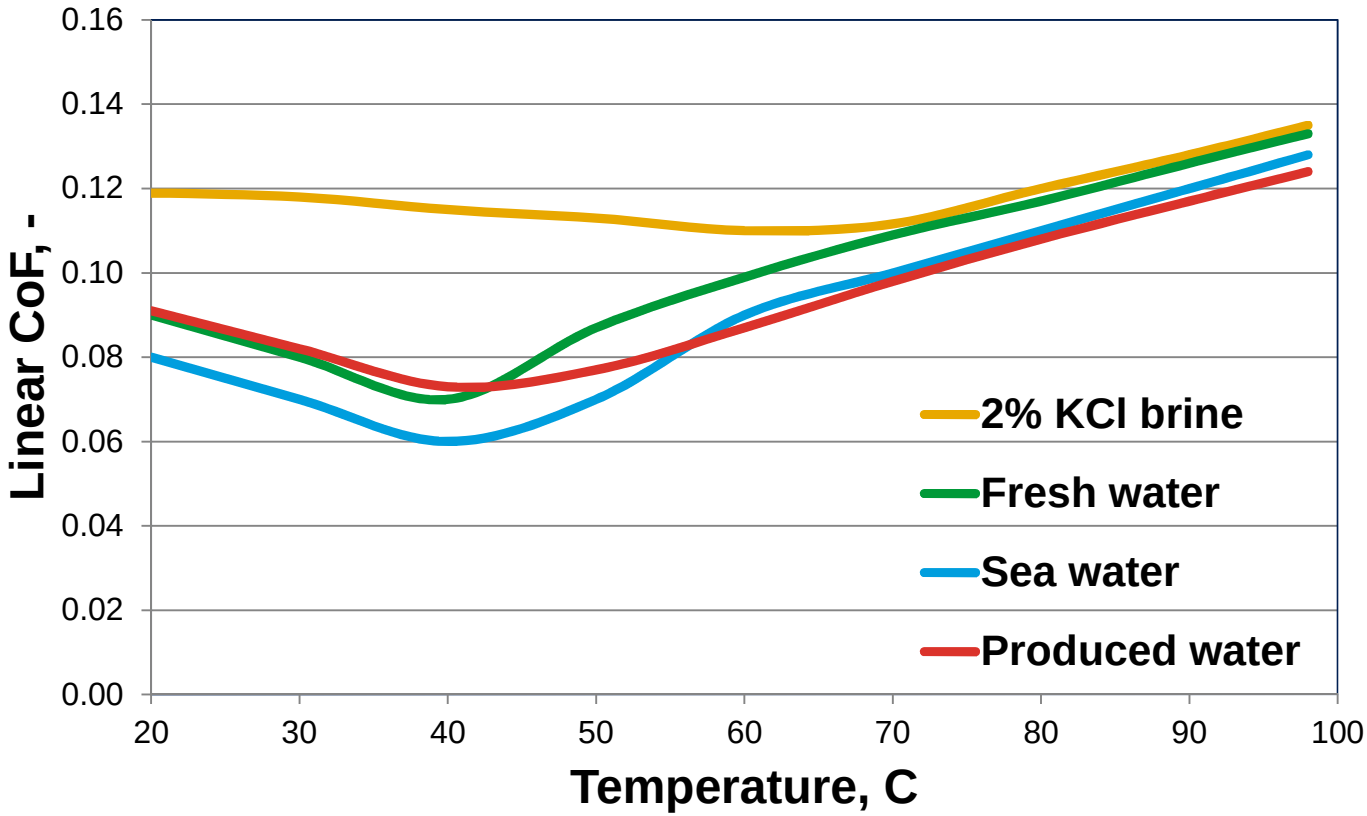
- Main variables (more than 6,600 tests)
  - Temperature
  - Well tubular metallurgy: P110 and Cr13
  - CT metallurgy: 90, 100ksi conventional and Cr16
  - 8 base fluids: tap water, fresh water, 2% KCl, seawater, produced water, 8% HCl, Diesel, mineral oil
  - 20 lubricants
  - 4 hydraulic friction reducers
  - pH
  - Sand/proppant

Rotational and Linear Friction Tests vs. Field Data

Lubricant	Rotational CoF at 20ºC	Linear CoF at 98ºC	Field Values
None	0.34	0.24	0.24 – 0.28
2% Existing Lubricant 1	0.04	0.22	0.19 – 0.22
2% Existing Lubricant 2	0.05	0.18	0.19 – 0.22
2% Advanced Lubricant	0.08	0.12	0.09 – 0.13

Comparative CoF values for current lubricants in 2% KCl Brine and 0.1% Hydraulic Friction Reducer

1% Advanced Lubricant CoF vs. Temperature



1% Advanced Lubricant mixed in Base Fluids and 0.1% Hydraulic Friction Reducer

Advanced Lubricant vs. Existing Lubricants
Other Tests

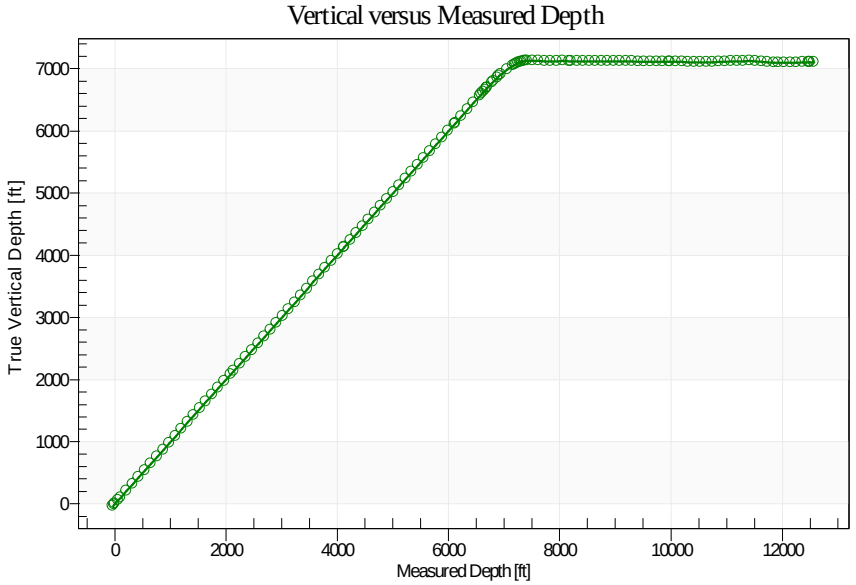
- Environment and Safety
  - Low hazard profile and low toxicity
  - North Sea approved, ongoing GoM approval

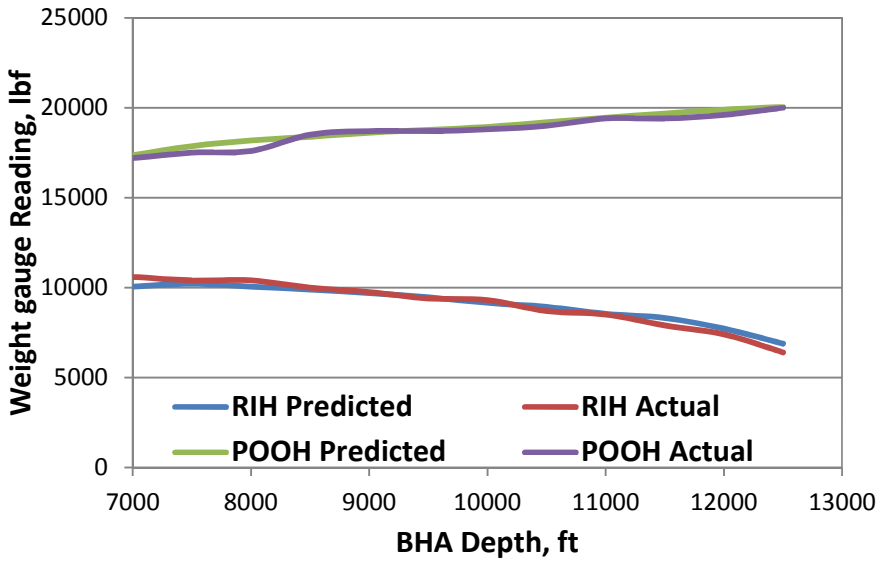
- Operator risk
  - Performs better than Existing Lubricants in regain perm tests in low-, medium-, and high-permeability cores
  - Performs better than Existing Lubricants in linear friction tests with produced water (up to 8% salinity)
  - Eliminates costly batch mixing and disposal problems with KCl brines

- Other tests
  - Compatible with other standard circulated chemicals for CT operations

Advanced Lubricant Case History 1 (North America)

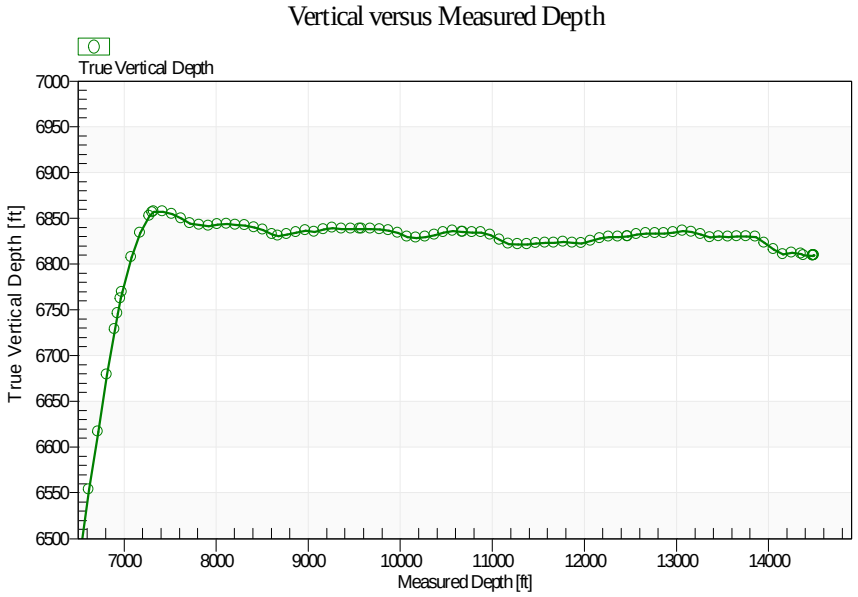
- 5 ½-in. J-shape with 5,100 ft lateral (89° to 93° inclination)
- Motor and mill scraper run with fluid hammer tool
  - CoF 0.22 RIH & POOH
- Annular fracture treatment with diversion achieved by utilizing a CT deployed packer
  - CoF 0.13 RIH & POOH
  - 1% Advanced Lubricant, 1 gpt Hydraulic Friction Reducer, Fresh Water

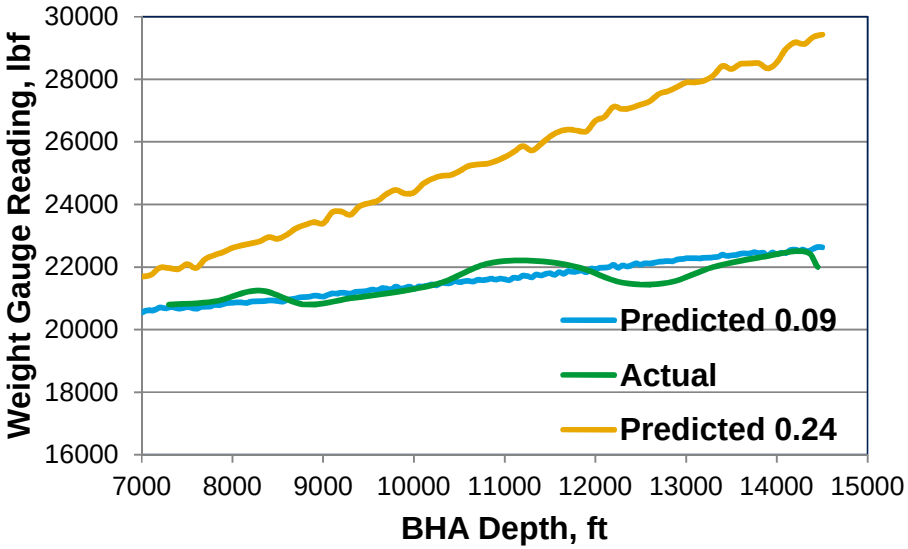




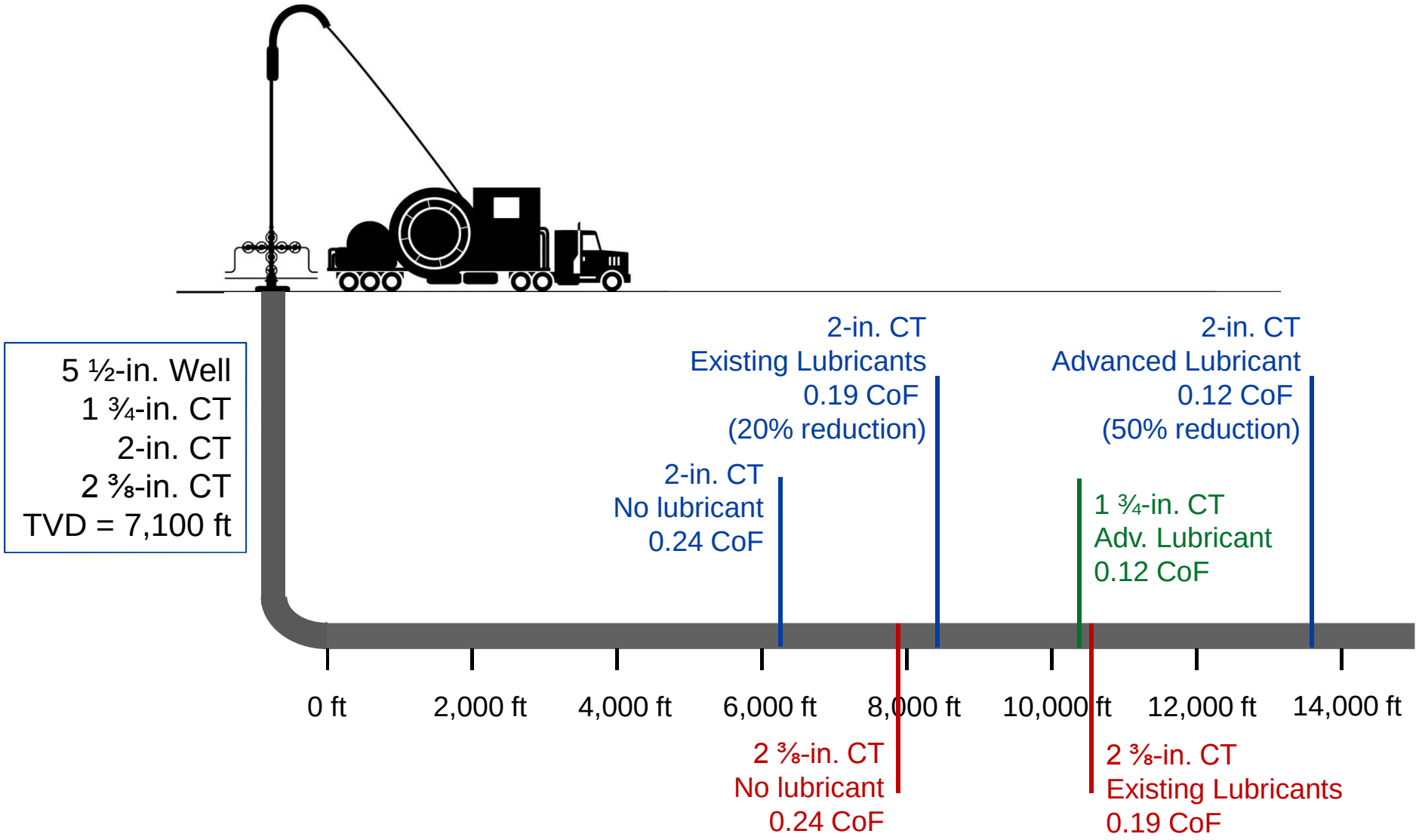
Advanced Lubricant Case History 2 (North America)

- 7-in. casing and 4 ½-in. liner J-shape with 7,200 ft lateral (90° to 92° inclination - average 90.4°)
- Ensure lateral access for a packer assembly BHA during an annular fracturing operation
  - CoF 0.09 RIH & POOH
  - 1% Advanced Lubricant, 1 gpt Hydraulic Friction Reducer, Fresh Water



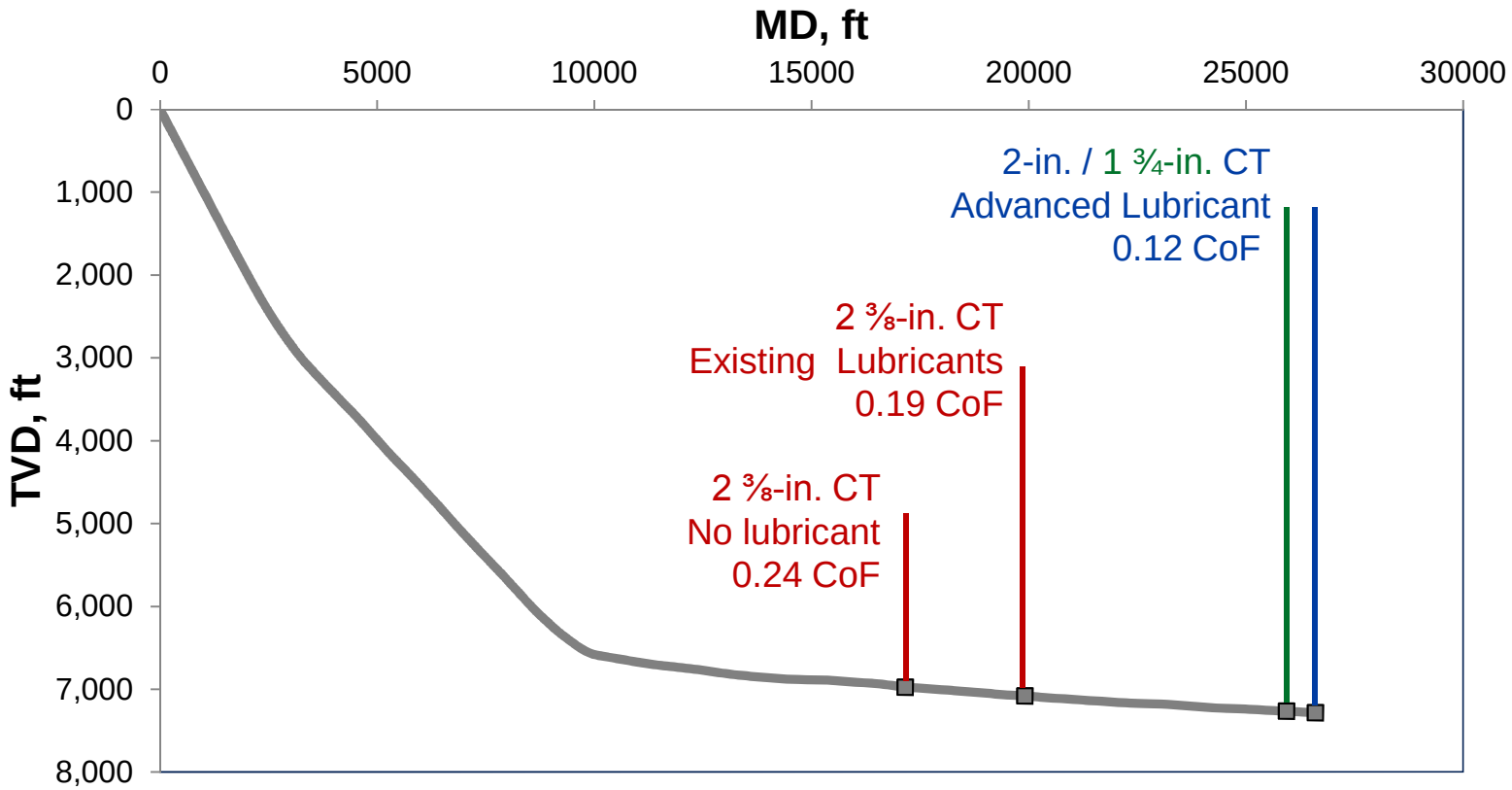


Advanced Lubricant Use Helps Decreasing CT Size
North America Case



Advanced Lubricant Use Helps Decreasing CT Size North Sea Case

- 4 ½-in. J-shape with 17,500 ft lateral (87° to 90° inclination)
- TD reached with 2-in. and almost with 1 ¾-in. CT / Advanced Lubricant



Smaller Size CT Operations

- Reported onshore/offshore operations
  - Scale removal
  - Solids cleanout
  - Milling
  - Perforating
  - Gas lift
- Potential onshore/offshore operations
  - Hydrate removal
  - Production logging / Fiber optic logging
  - Fishing
  - Remedial cementing
  - Thru-tubing inflatable packer deployment
- Potential fracturing operations
  - When well/completion size limits CT size
    - Hybrid fracturing sleeves, ball seats, toe shoot, small BHA, etc.
  - Annular fracturing through larger annuli
    - 12% and 18% lower pressure drops in 5 ½-in. well with 2- and 1 ¾-in. CT versus 2 ⅜-in. CT
    - 19% and 28% lower pressure drops in 4 ½-in. well with 2- and 1 ¾-in. CT versus 2 ⅜-in. CT

Conclusions

- Advanced Lubricant reduces linear CoF by approximately 50% (from the default CoF of 0.24 to 0.09 - 0.13) under downhole conditions
- Approximately 50% friction reduction is expected to essentially double the reach in long lateral wells
- Depending on the specific job performed and its requirements, Advanced Lubricant could help reduce the CT size significantly, such as from 2 ⅜-in. to 2-in. and even 1 ¾-in.
- Reducing CT size translates in direct CT purchase cost savings, lower operational costs and carbon footprint, and lower risk of damage/fatigue
- Advanced Lubricant performs better than Existing Lubricants in regain perm tests and in linear friction tests when mixed in produced water

Conclusions (Continued)

- The rotational friction testers are continuously optimistic in terms of CoF reductions when compared to post-job matched data

- CoF mostly depends on
  - Downhole temperature
  - Contact surface (CT and casing) roughness
  - Fluid type and chemistry

- The presence of sand, proppant, and debris increases CoF by increasing the contact surface roughness

- Any laboratory or field CoF should be specified together with the conditions (i.e., temperature and contact surface roughness) at each was measured and/or calculated

Acknowledgements

- John Misselbrook
- John Delorey
- Steven Craig
- Tom Watkins
- CTRE/Baker Hughes Staff

Questions? Further Reading

SPE168299 – “Water Hammer Modeling in Extended Reach Wells” presented at SPE/ICoTA Well Intervention and Coiled Tubing Conference and Exhibition held in The Woodlands, TX, USA, 2014

SPE 168298 – “Increasing Lubricity of Downhole Fluids for Coiled Tubing Operations”, presented at SPE/ICoTA Well Intervention and Coiled Tubing Conference and Exhibition held in The Woodlands, TX, USA, 2014

SPE 168299 – “Analytical Downhole Temperature Model for Coiled Tubing Operations”, presented at SPE/ICoTA Well Intervention and Coiled Tubing Conference and Exhibition held in The Woodlands, TX, USA, 2014

SPE 170635 – “Challenging the Industry's Understanding of the Mechanical Friction Reduction for Coiled Tubing Operations”, presented at the SPE Annual Technical Conference and Exhibition held in Amsterdam, The Netherlands, 2014

IPTC 17815 – “Smaller Coiled Tubing Diameter Achievable by the Use of Lubricants”, to be presented at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia, 2014

SPE 173683 – “Overcoming Extended-Reach Challenges for Annular Fracturing”, to be presented at SPE/ICoTA Well Intervention and Coiled Tubing Conference and Exhibition held in The Woodlands, TX, USA, 2015