High-Density Zinc Free Brine

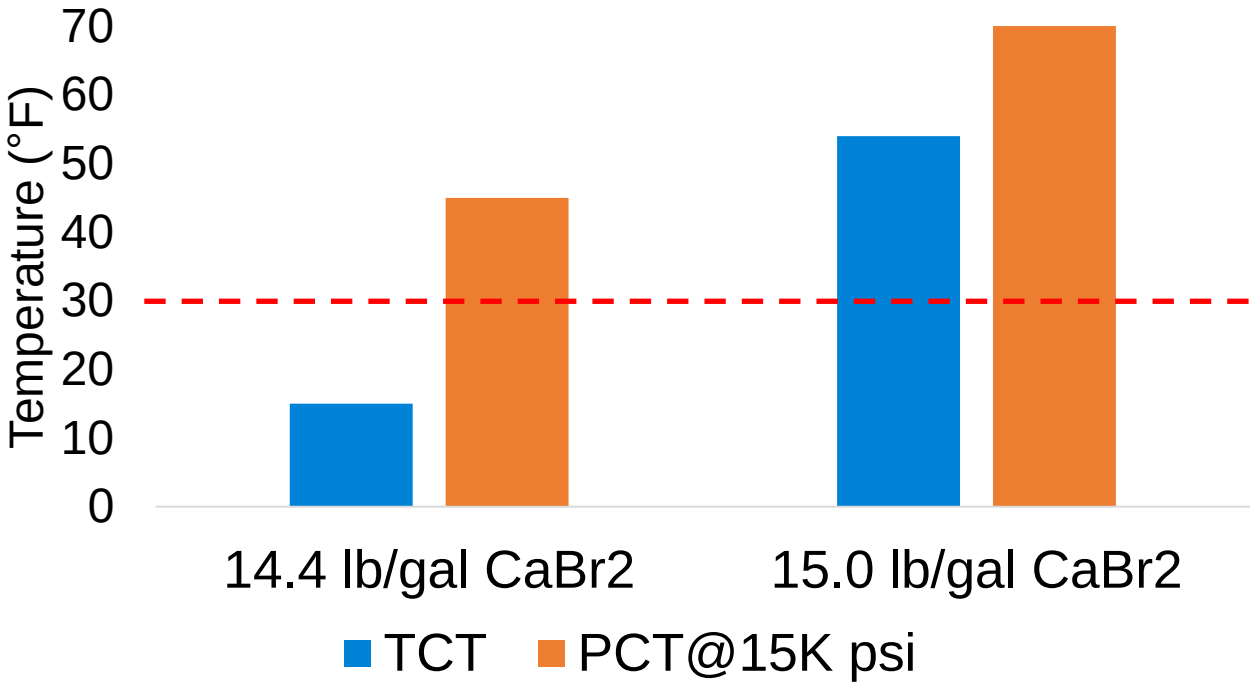
Mathieu Champeau, Product Champion

October 9, 2018



Schlumberger-Private

The Case for a Zinc-Free (ZF) Brine



$CaBr_2$





HSE

Corrosion

Disposal

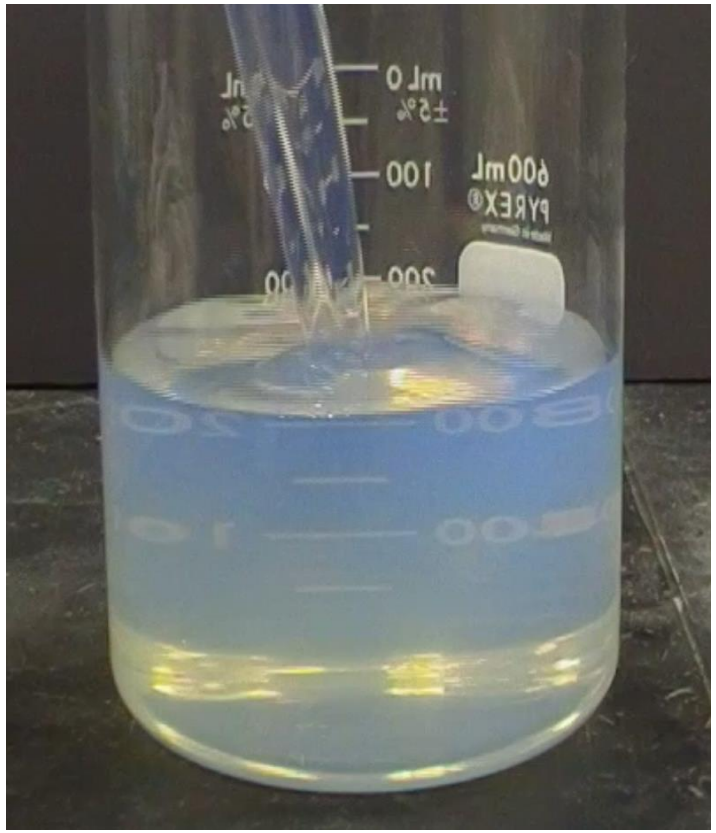
Cost

Total Cost of Ownership

$ZnBr_2$

Fluid Description

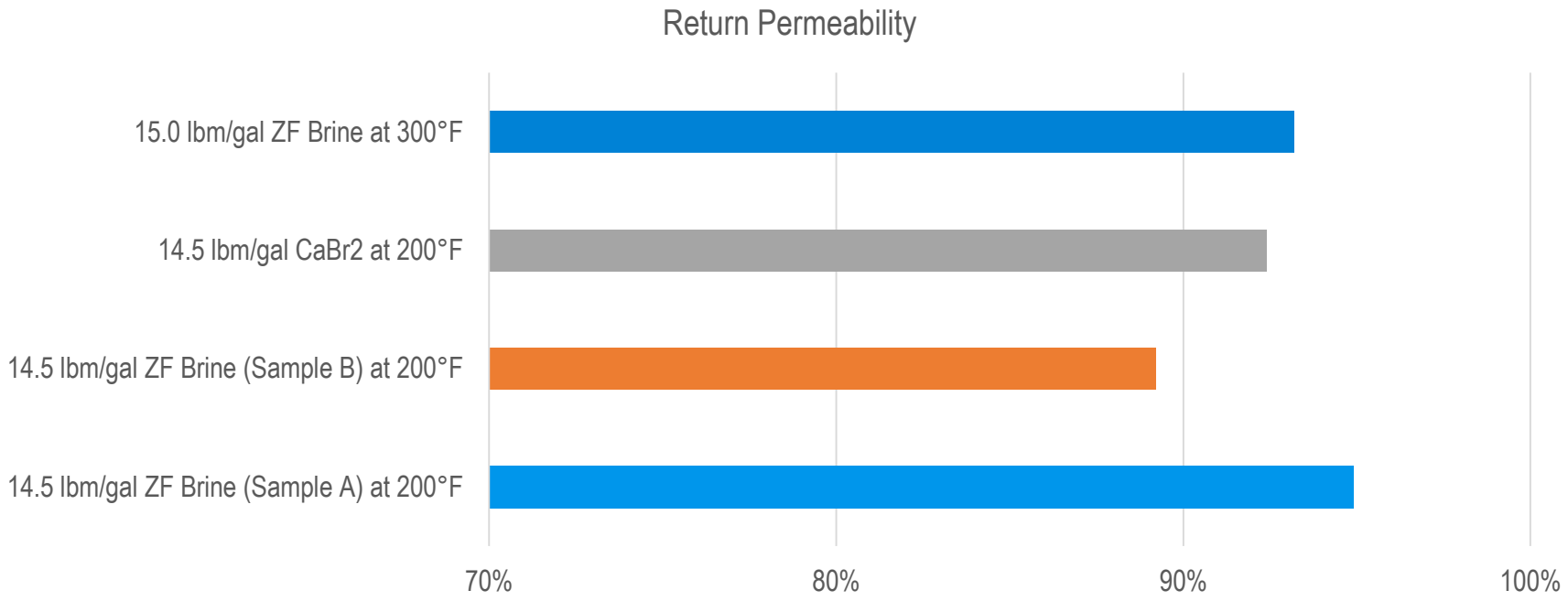
- 15.4 lbm/gal stock fluid
  - Optimized to meet strict crystalline temperature requirements – PCT < 30°F (-1°C) at 15,000 psi
- $CaBr_2$ base brine with minute inert weight material for density
  - Minimal formation damage
  - Lower corrosion rate
  - Improved density maintenance compared to saturated brine
  - Compatible with $CaBr_2$ compatible elastomers



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Fluid Performance

- Return permeability results comparable to calcium bromide
  - Particles too small to plug or bridge production pores



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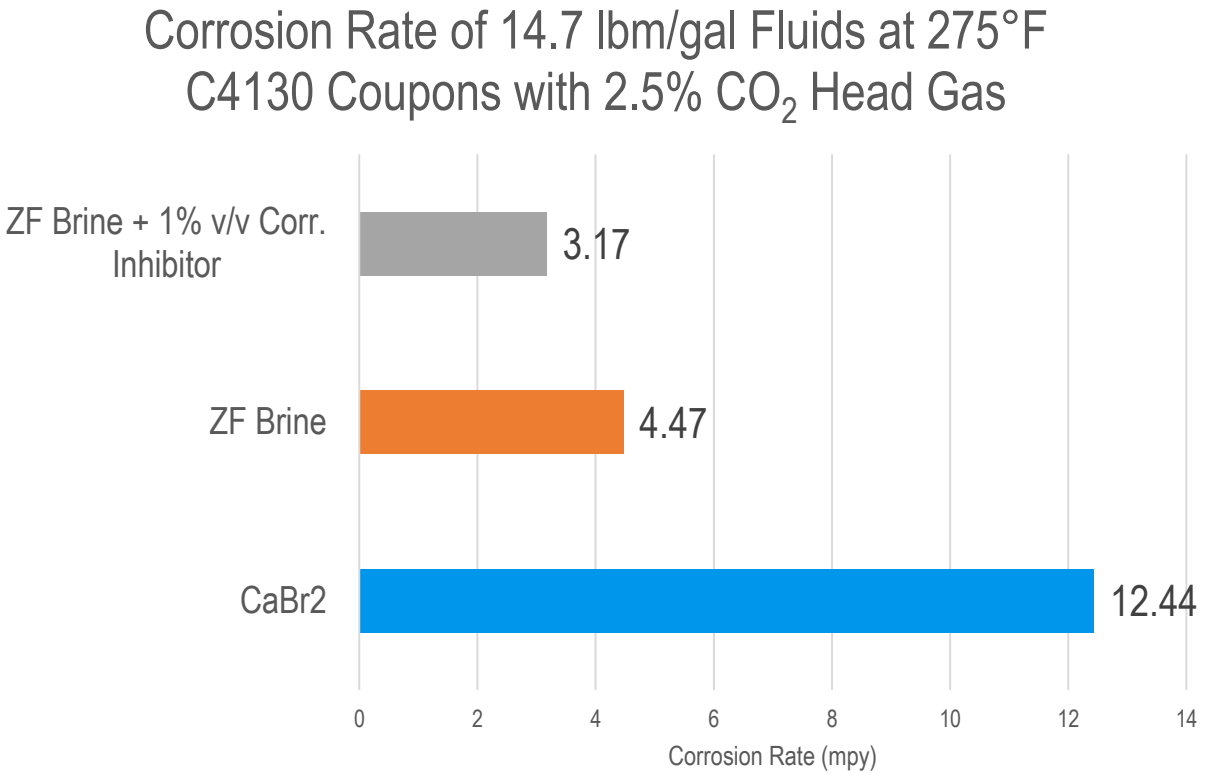
Fluid Performance

- Behaves like $CaBr_2$
  - Elastomers such as HNBR, Aflax
- Compatible with typical completion fluid additives
  - Nonemulsifier
  - Scale Inhibitor
  - Oxygen Scavenger
  - Corrosion Inhibitor
  - Defoamer
  - Packer Fluid
  - Methanol, xylene, hydrate inhibitors, control line fluids – test for specific products and conditions



Elastomer Immersion Test

Fluid Performance



- Lower salinity and solid particles dramatically reduce corrosion rate
- Testing shows no signs of stress corrosion cracking in 13Cr-110

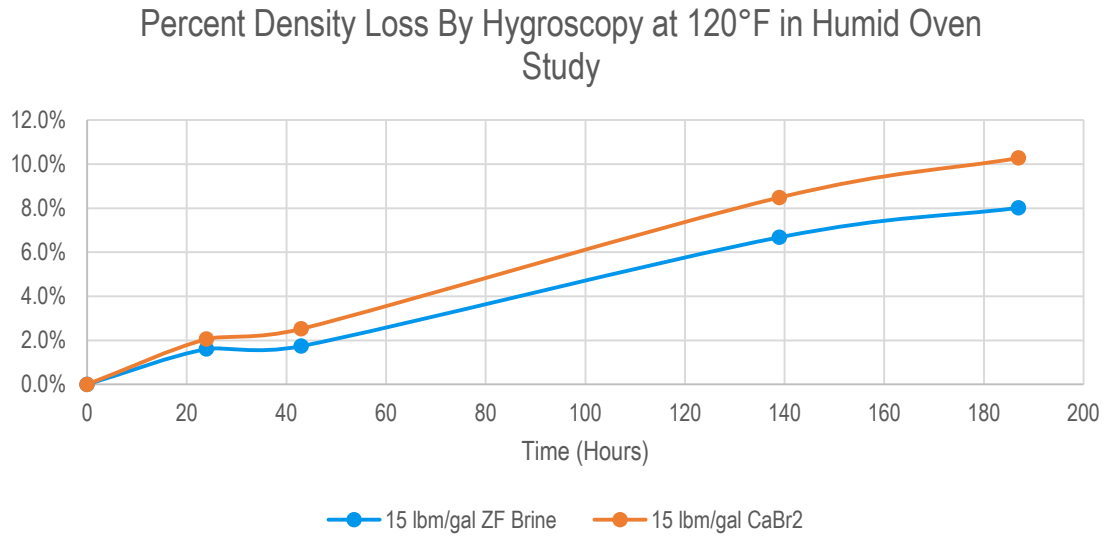


13Cr-110 Corrosion Rings after 30-Day Test

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Fluid Advantages

- Lower density brine component lowers rate of hygroscopy
- Saturated brines absorb water from the atmosphere, lowering overall density
  - Dry salt or spike fluid additions required at increased intervals
- Brine viscosity allows to pump at high flow rates

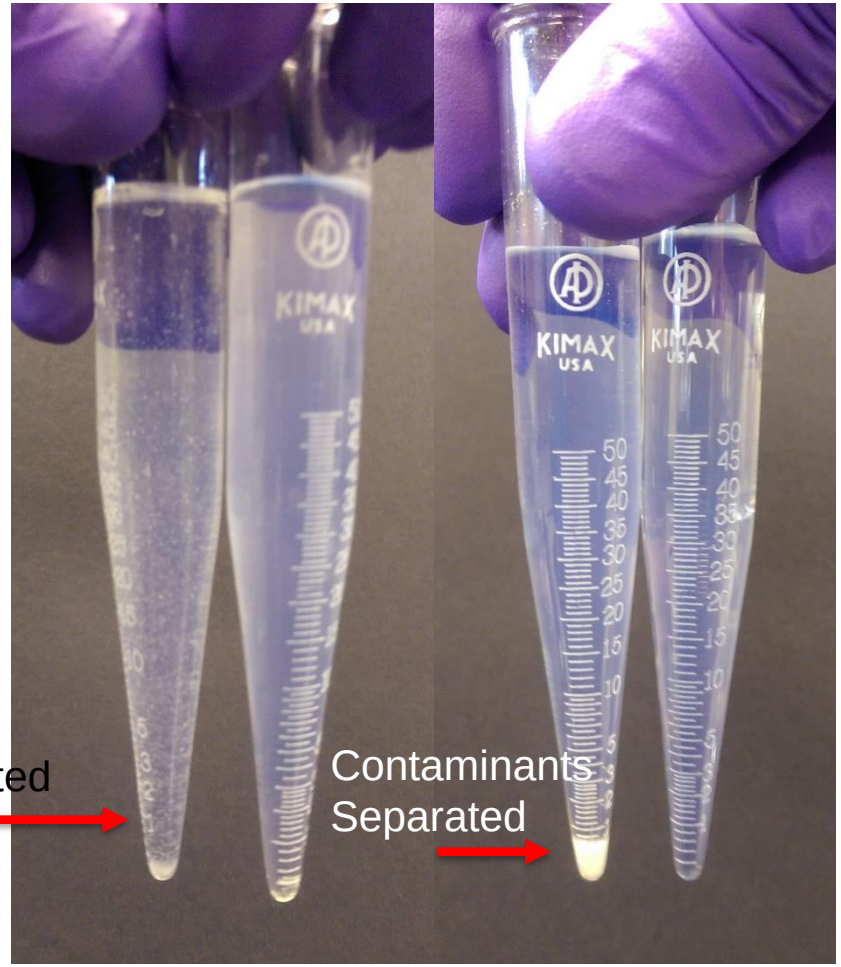


Property	14.5 lbm/gal ZF Brine	15.0 lbm/gal ZF Brine	15.4 lbm/gal Spike Fluid
Viscosity at 40°F	16.5 cP	24 cP	48 cP
Viscosity at 72°F	9.5 cP	16 cP	33 cP
Viscosity at 120°F	6.2 cP	8.8 cP	17.5 cP

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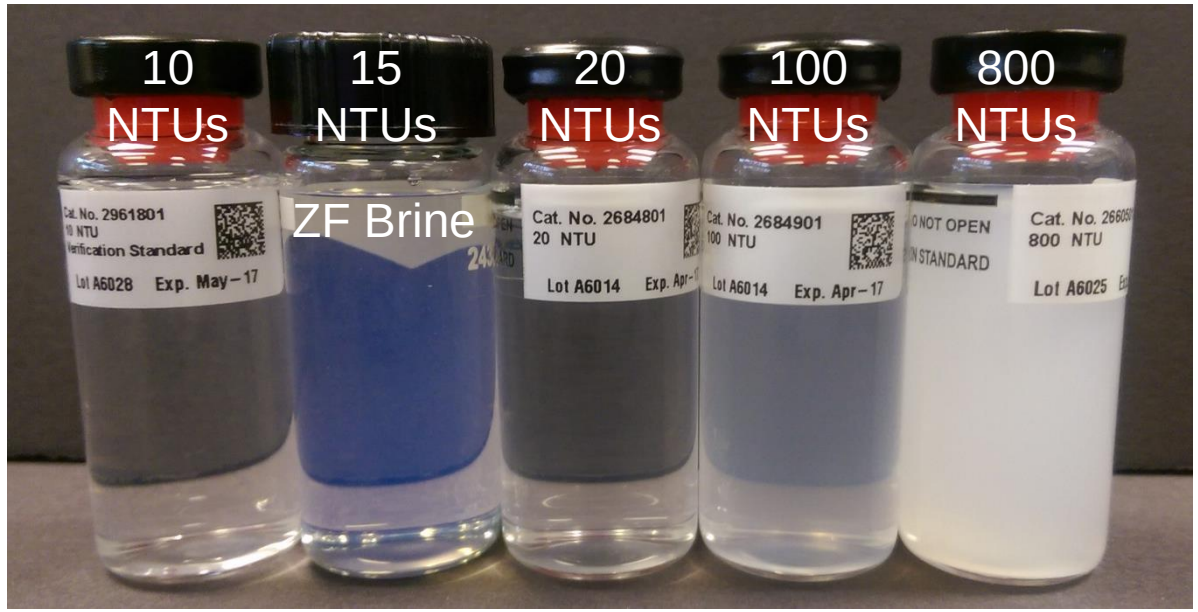
ZF Brine Maintenance - Solids

- The weight material is too small for a conventional centrifuge to separate it from the fluid
  - Contaminants such as sand are separated using a conventional test (example to the right – leftmost tube contains solids while the rightmost is uncontaminated)
  - Weight material naturally stays in suspension and does not sag
- Other solids are easily removed with standard filtration equipment



ZF Brine Maintenance - Clarity

- ZF Brine has a bluish tinge and slightly higher NTU readings than typical brine
  - Not significantly higher under circulating conditions



ZF Brine Versus Calibration Standards of Various Clarity

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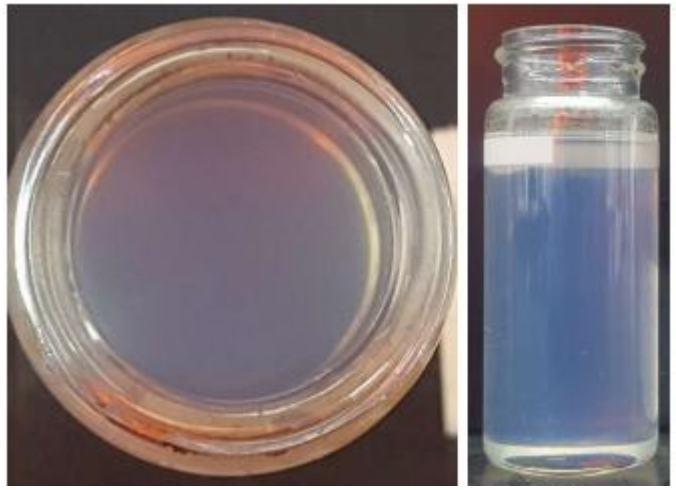
ZF Brine Field Trial

- Used in a offshore, cold weather environment, to act as barrier
- ZF Brine was diluted to 14.85 lbm/gal in stages, at LMP first and then at rigsite
  - 10 days static in well at 160°F
  - No variation in color, density or any other property
  - Behaved like standard $CaBr_2$ brine
- Completion was run successfully without any issue



ZF Brine Field Trial - Backload

- No indication of contamination
- Only filter press filtration was required to bring brine back to specs
- Brine transferred to IBC for long-term storage



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