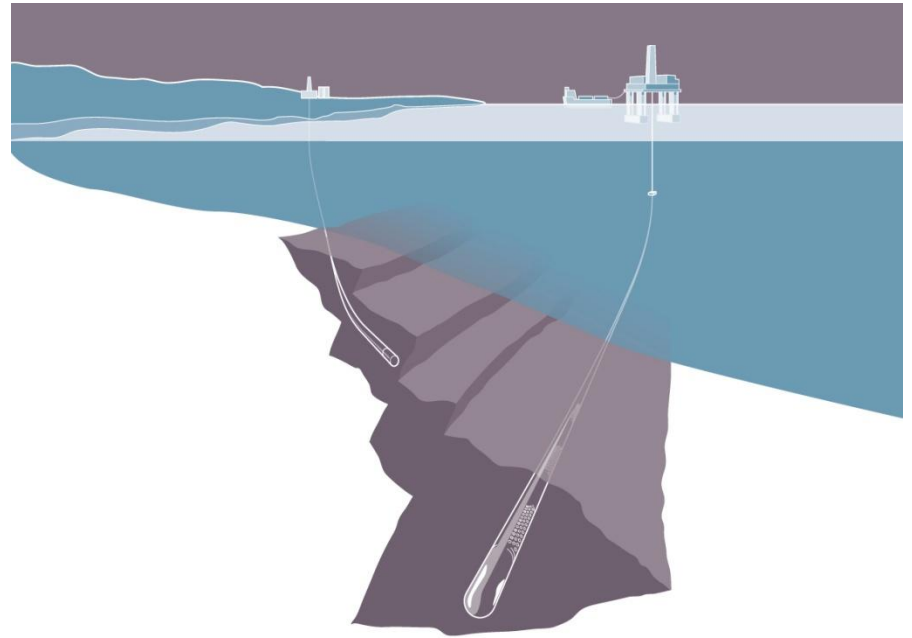


Deepwater Completion Fluids

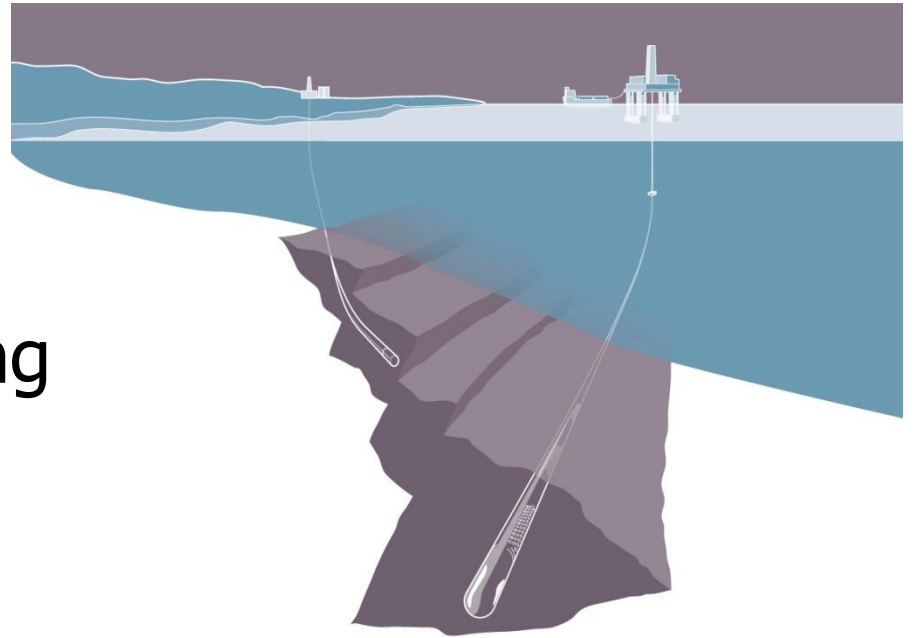
John Vian
18 November 2009

Are we really up to
the challenge?



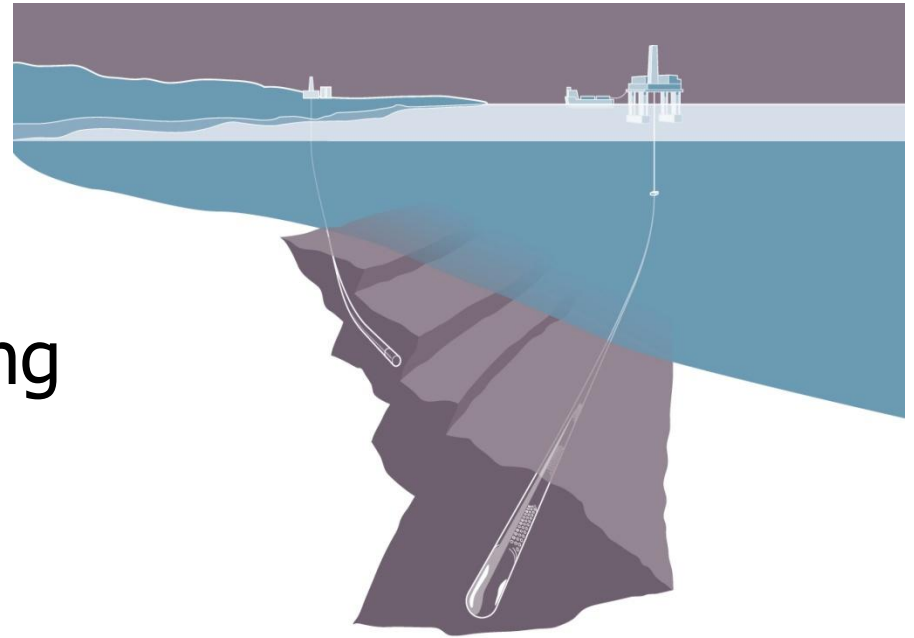
Are we really up to the challenge?

- Logistics and Planning



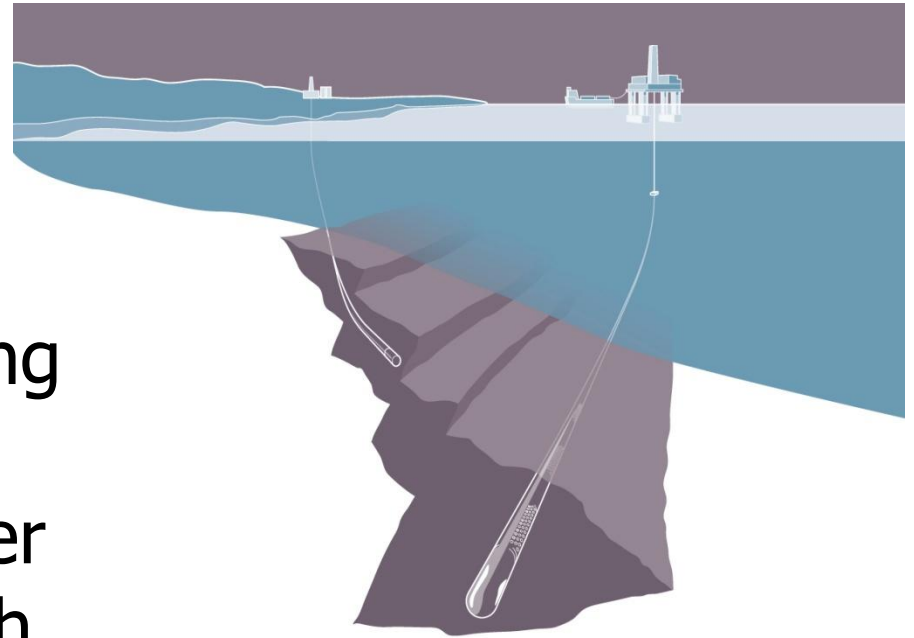
Are we really up to the challenge?

- Logistics and Planning
- Brine availability



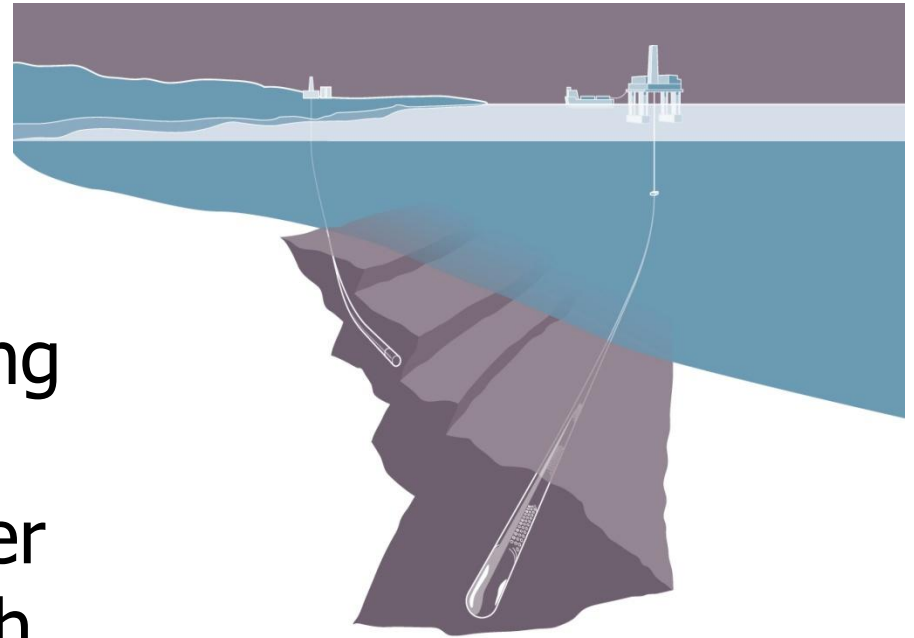
Are we really up to the challenge?

- Logistics and Planning
- Brine availability
- Almost all deep water wells are drilled with SBM



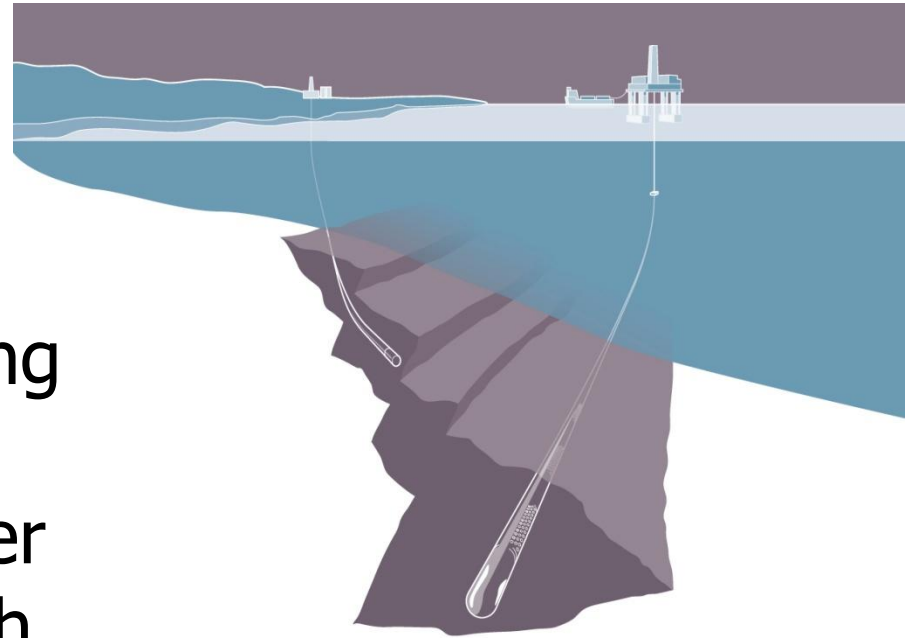
Are we really up to the challenge?

- Logistics and Planning
- Brine availability
- Almost all deep water wells are drilled with SBM
- Cold Temperatures



Are we really up to the challenge?

- Logistics and Planning
- Brine availability
- Almost all deep water wells are drilled with SBM
- Cold Temperatures
- Corrosion Concerns

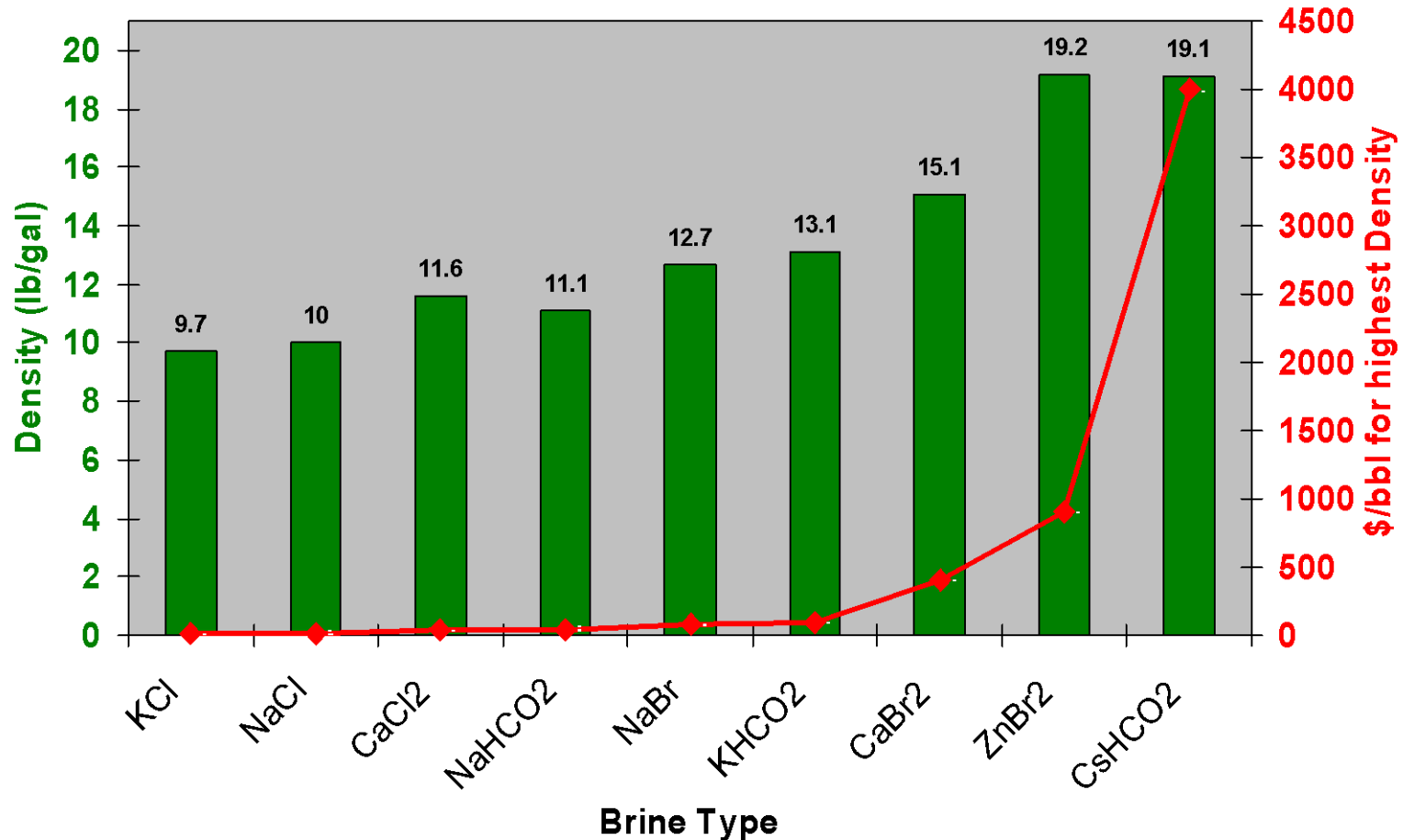


COMPLETION FLUID SELECTION

- Density
 - Salt types

COMPLETION FLUID SELECTION

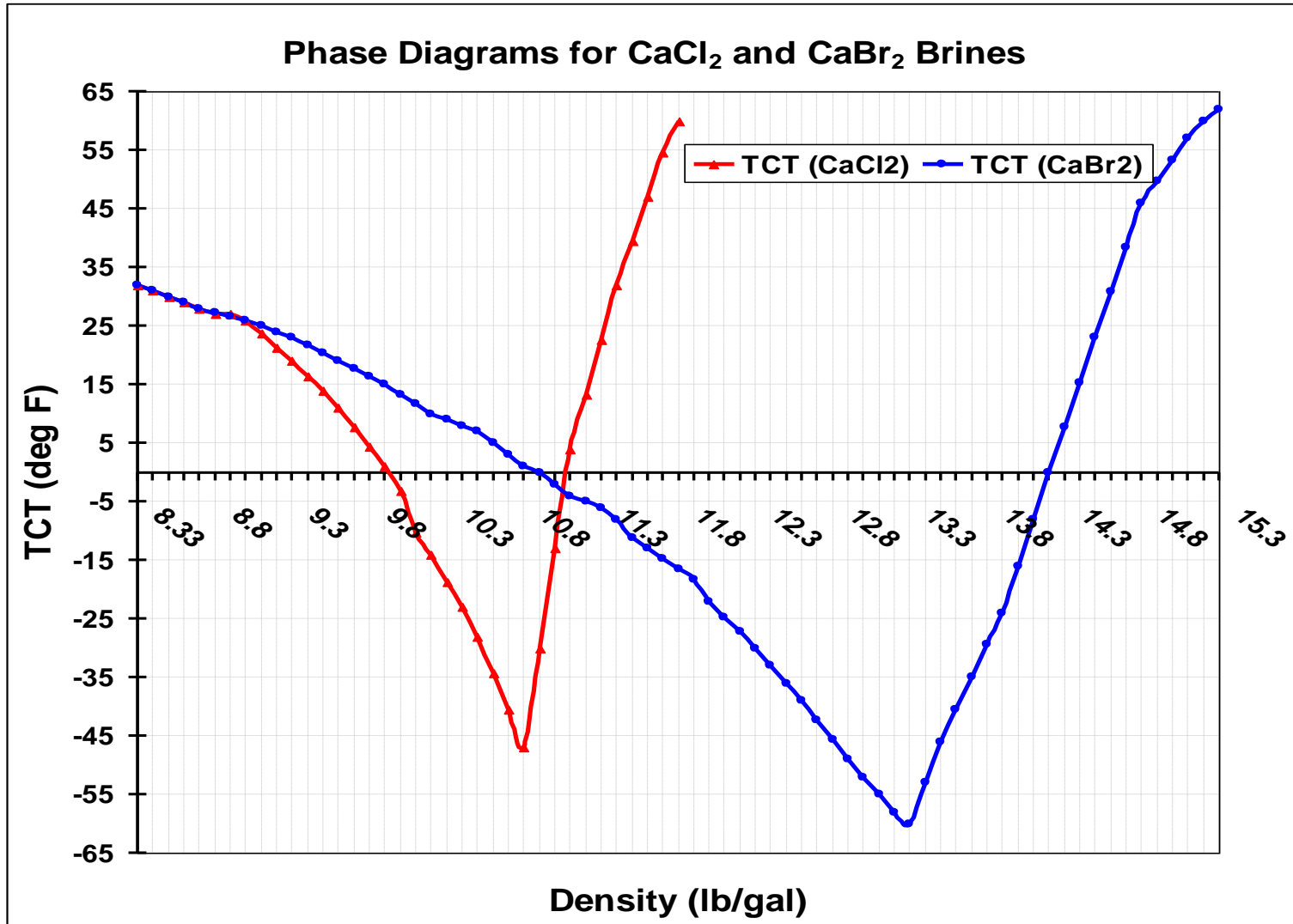
Density – Brine type - Cost



COMPLETION FLUID SELECTION

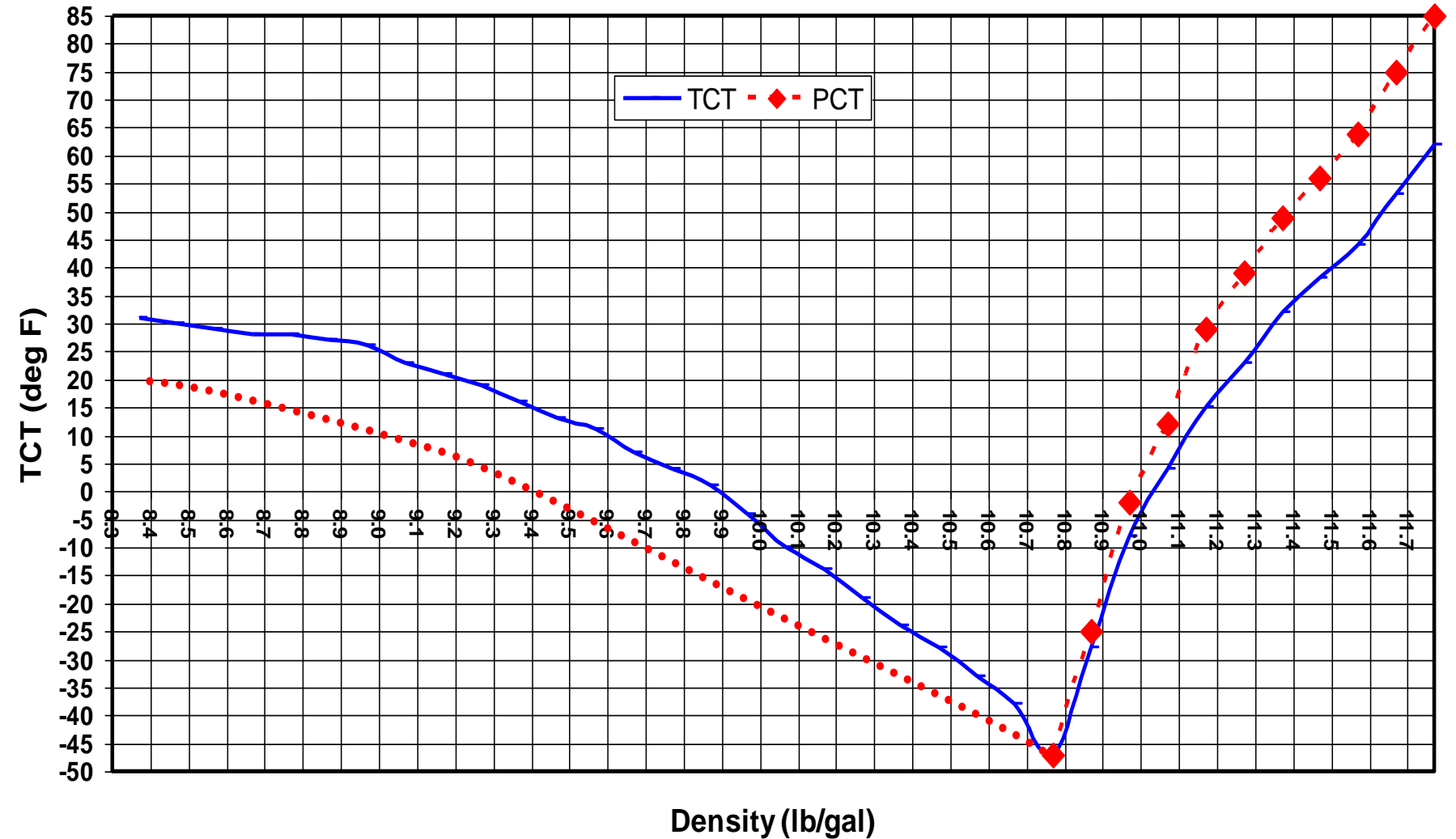
- Density
 - Salt types
- Crystallization Temperature
 - Thermodynamic Crystallization Temp. – TCT

COMPLETION FLUID SELECTION



COMPLETION FLUID SELECTION

Effect of 10,000 psi Pressure on TCT of CaCl₂



COMPLETION FLUID SELECTION



COMPLETION FLUID SELECTION

- Density
 - Salt types
- Crystallization Temperature
 - Thermodynamic Crystallization Temp. – TCT
- Formation Damage
 - Compatibility with Rock Matrix
 - Compatibility with Formation Fluids

Compatibility with Rock Matrix



Compatibility with Formation Fluids



14.8 lb/gal Zn-CaBr₂ with synthetic formation water.

COMPLETION FLUID SELECTION

- Density
 - Salt types
- Crystallization Temperature
 - Thermodynamic Crystallization Temp. – TCT
- Formation Damage
 - Compatibility with Rock Matrix
 - Compatibility with Formation Fluids
- Corrosion

COMPLETION FLUID SELECTION

Corrosion Rates for Brines Without Inhibitor (N-80 Steel, 30 Days, mpy)

Brine Type	Density (lb/gal)	70°F	150°F	250°F	300°F	350°F
NaCl	10.0	0.5	1.5	0.2	0.1	0.1
NaCl / NaBr	11.2	0.4	0.7	0.1	0.1	0.1
CaCl ₂	12.4	0.3	0.4	0.1	0.1	0.1
NaBr	11.6	0.1	0.2	0.7	0.9	1.9
CaCl ₂ / CaBr ₂	13.6	0.3	0.9	1.6	1.6	3.0
CaCl ₂ / CaBr ₂	15.1	0.1	0.5	2.4	2.9	6.6
ZnBr ₂ / CaCl ₂ / CaBr ₂	17.0	0.1	0.3	10.0	13.4	19.8
ZnBr ₂ / CaCl ₂ / CaBr ₂	19.2	0.1	1.0	35.3	67.4	79.8

COMPLETION FLUID SELECTION

Deeper wells need higher strength tubing

- 13Cr is the most popular metallurgy in deepwater
- Yield Strength > 95kpsi but prone to SCC
- Chlorides induce CSCC

Duplex stainless steels (22-28 Cr)

- Less susceptible to SCC than 13Cr
- Thiocyanate inhibitors should be avoided

Chloride Stress Crack Failure

Calcium chloride packer fluid failure



Chloride Stress Crack Failure



**14.2 ppg CaBr₂ at 295F
4800 psi N₂ + 200 psi CO₂
HP1-13Cr 110 ksi**

14.2 lb/gal CaBr₂
Blank



COMPLETION FLUID SELECTION

- Density
 - Salt types
- Crystallization Temperature
 - Thermodynamic Crystallization Temp. – TCT
- Formation Damage
 - Compatibility with Rock Matrix
 - Compatibility with Formation Fluids
- Corrosion
- **HSE**

LOGISTICS AND PLANNING

- Planning is key
- Is there enough space for fluids?
- Motor Vessels typically hold 8,000 to 10,000 bbls
 - Longer boat rides to transport materials
- How many filter presses?
- Almost always SBM used for drilling
- Highly deviated wells

Cold Environment

- TCT & PCT issues
- Hydrate concerns
- Insulating Packer Fluid
 - Provides Flow Assurance
- Chemistry of Additives
 - Is your spacer system designed to perform at 38 F?
 - Can't rotate. Concentric pipe.

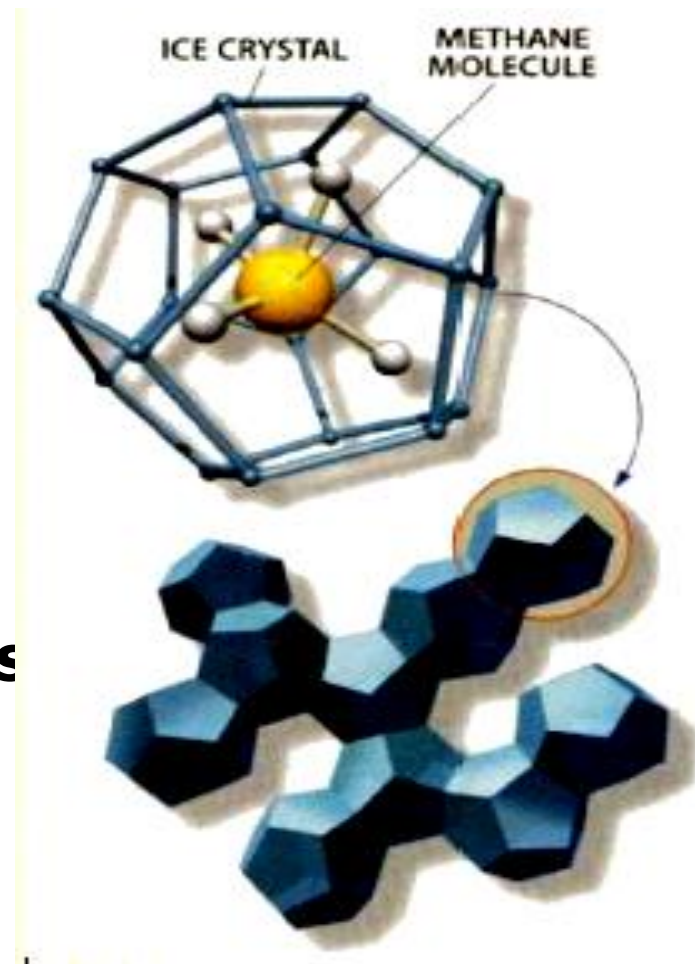
Hydrate Formation

Water forms a cage-like structure around a gas molecule:

Methane
Ethane
Propane
Isobutane
Normal butane
Nitrogen
Carbon dioxide
Hydrogen sulfide

Hydrate formation requires

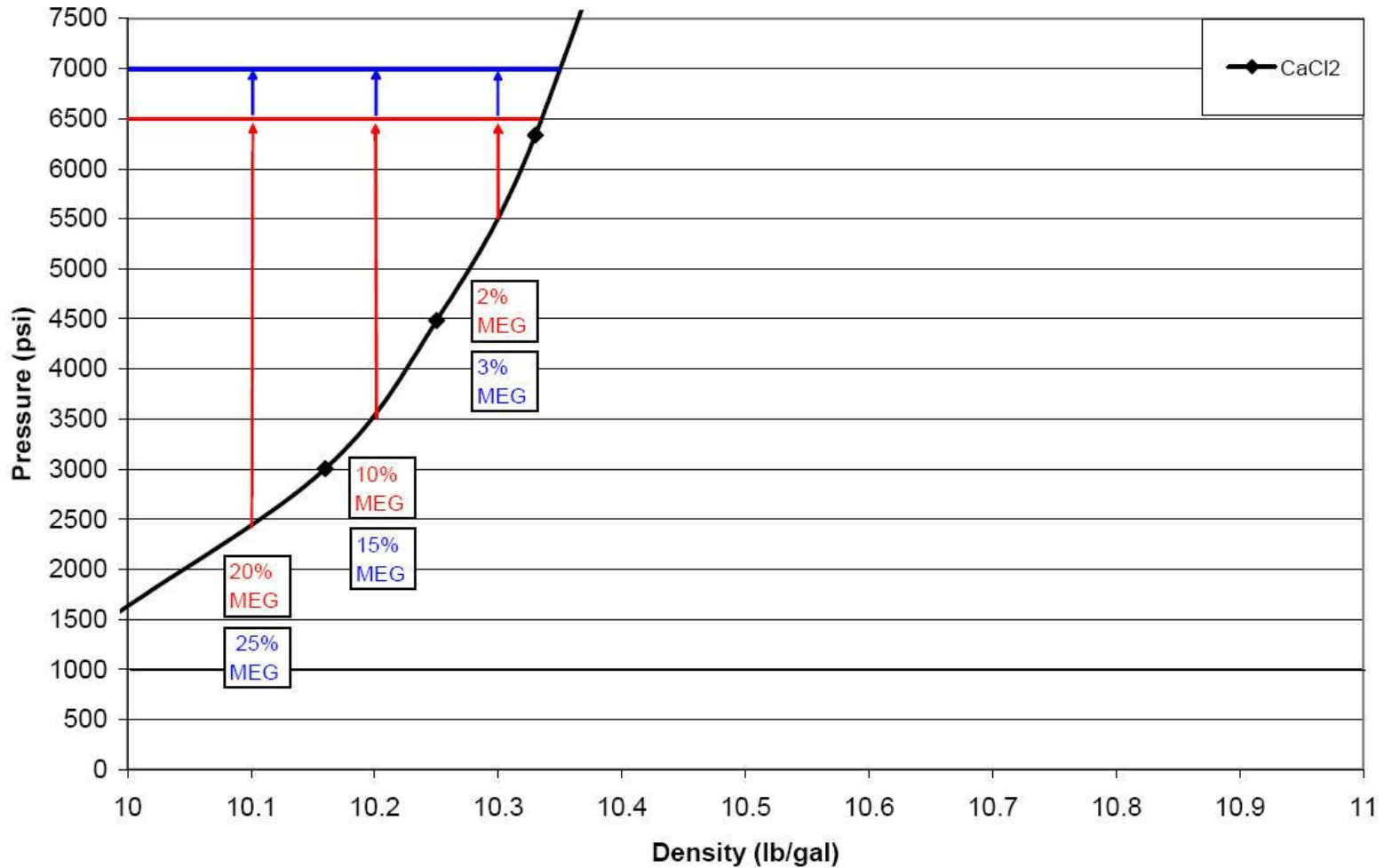
Water
Gas
Low temperature
High pressure



Hydrate Prevention

WHYPs Calcium Chloride Hydrate Prediction at 38°F

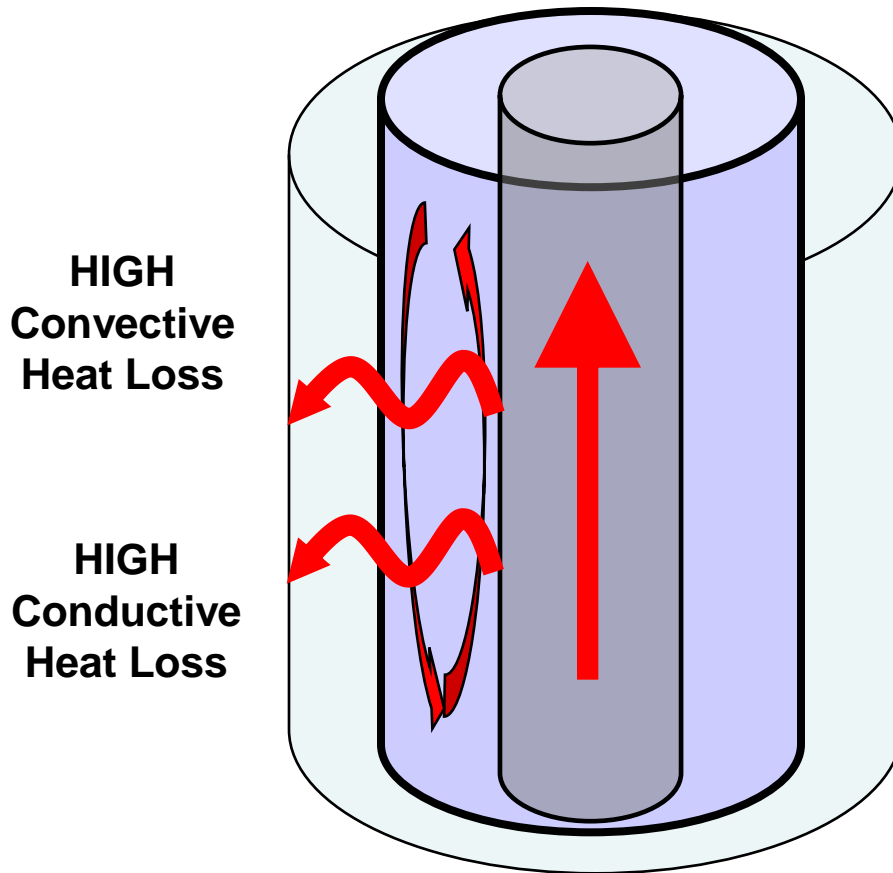
Green Canyon Gas



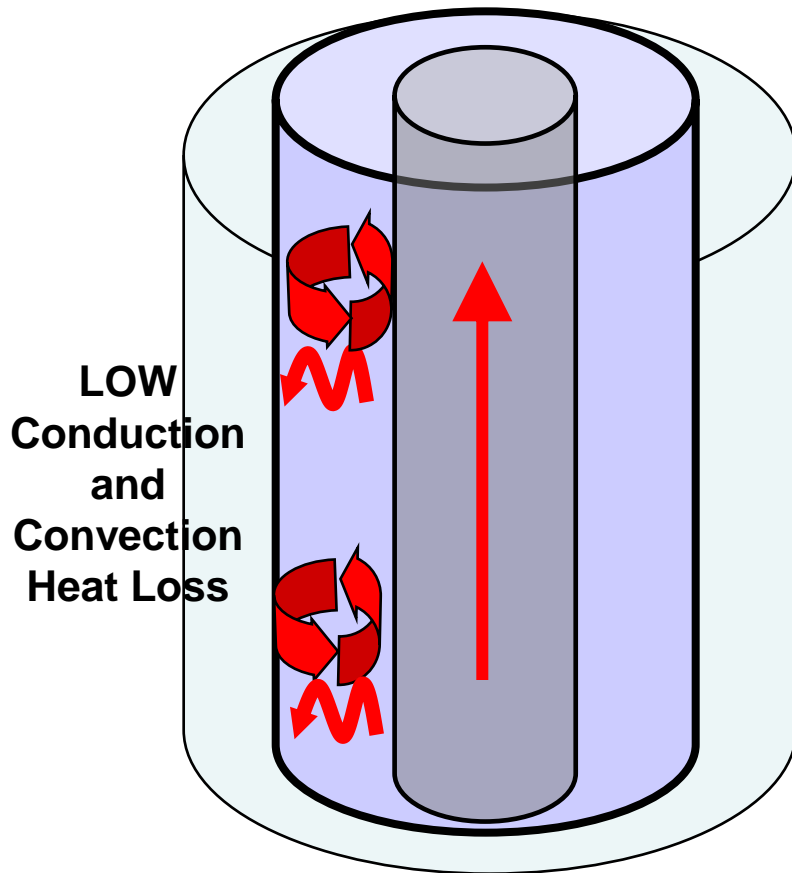
Insulating Packer Fluids

- A fluid placed in an annulus to reduce heat loss from the production tubing through the annulus by means of conduction and convection
- Typically, IPF is placed in the "A" or "B" annulus
- Formulated according to insulation specification required by wellbore design and fluid performance specification
- Prepared from a low thermally conductive base fluid and viscified in a special manner to reduce convection
- Conductive heat loss is reduced with the base fluid
- Convective heat loss is reduced by producing a yield-stress at the wall greater than yield stress induced by ΔT

Heat Loss through Production Tubing/Annulus

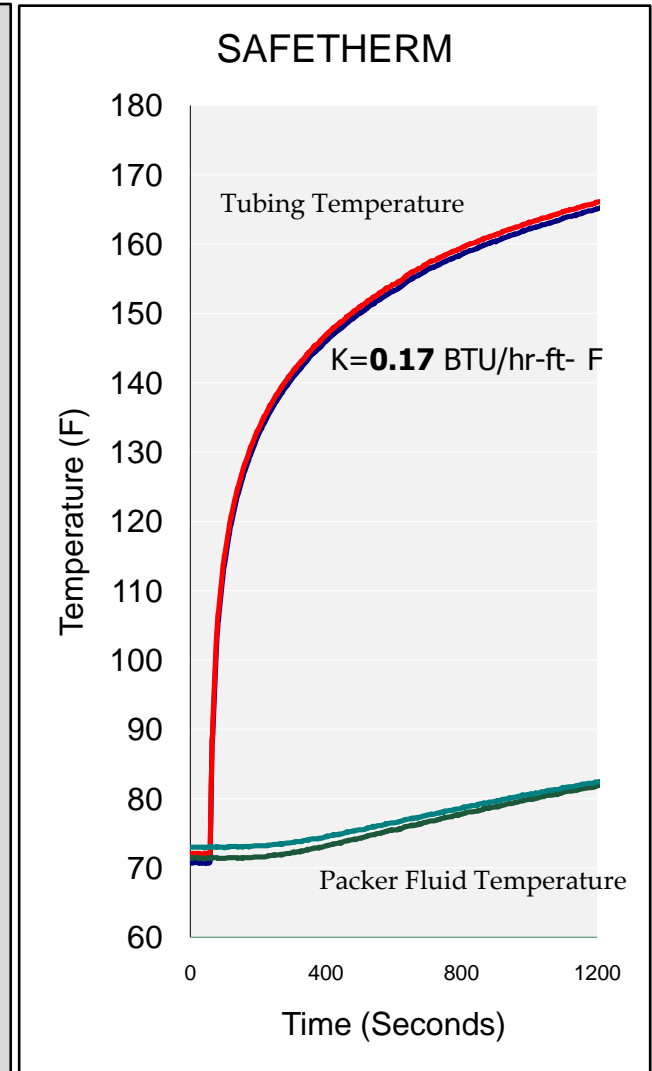
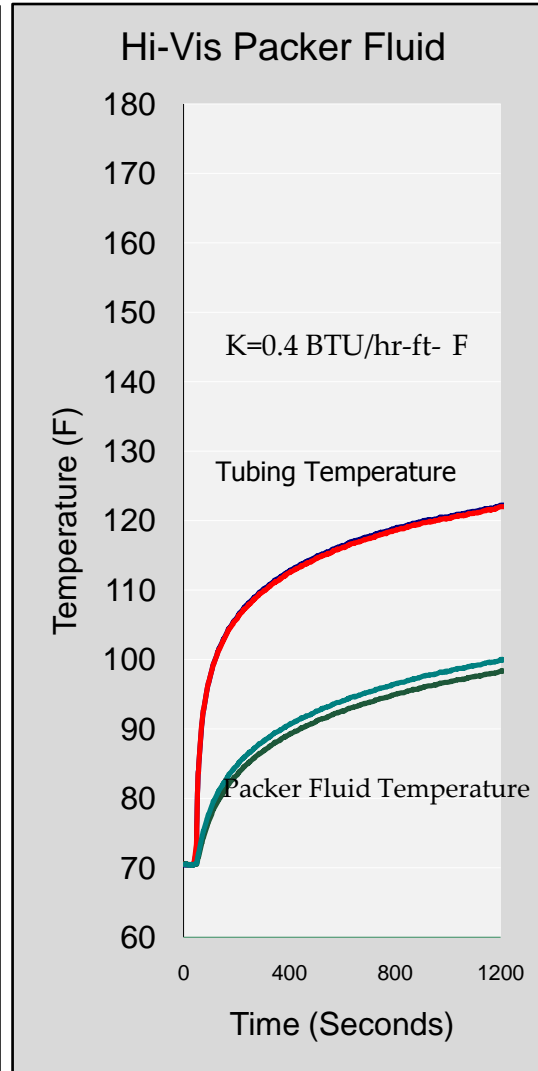
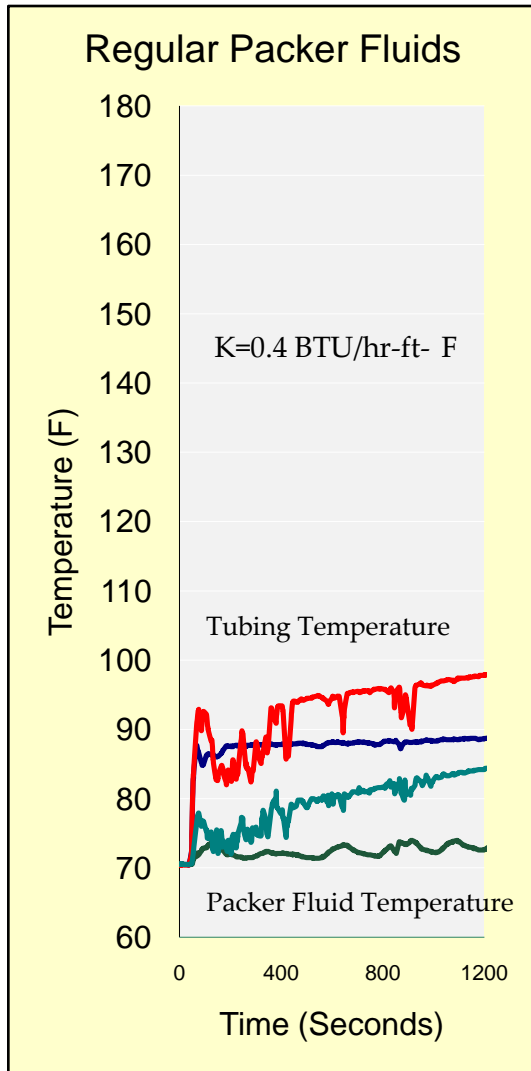


Insulate the Production Tubing



- **Insulate production tubing....**
 - Increase T of produced fluid
 - Prevent paraffin build-up & hydrate formation
- **Slow critical heat loss**
 - increase available shut-in time
- **Reduce negative heat transfer rate to external casings**
 - Prevent casing collapse
 - Prevent casing pressure
 - Protect VIT

Insulating Packer Fluid

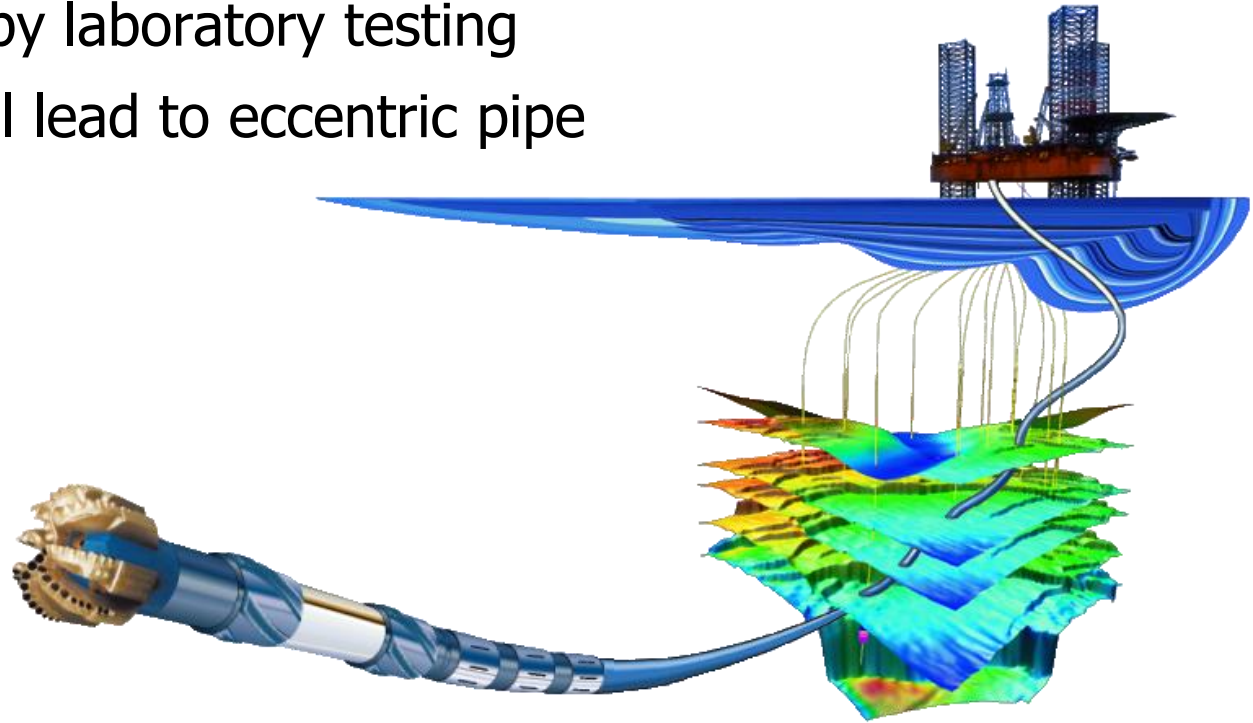


Necessary Properties for Insulating Packer Fluids

- Low thermal conductivity
- High viscosity*
 - *Yield stress and LSRV
 - Stable low shear rate viscosity
 - Eliminates thermal convection
- Long-term stability
- High heat capacity
- Low corrosivity
- Appropriate density for annuli design
- No suspended solids
- Compatibility with wellbore construction / fluids

CLEANING SPACERS

Only one shot for displacing the SBM
Prevent NPT by laboratory testing
Deviations will lead to eccentric pipe



Cleaning Spacer Design

11.6 ppg 3% Safe Solv OM 5% Safe Surf O 0% Contamination and 13.2ppg Nova Plus @100rpm/ 42fpm



Clean Dry Sleeve



Sleeve Coated with 13.2 ppg SBM



After 3 Minutes Rating 2



After 5 Minutes Rating 2

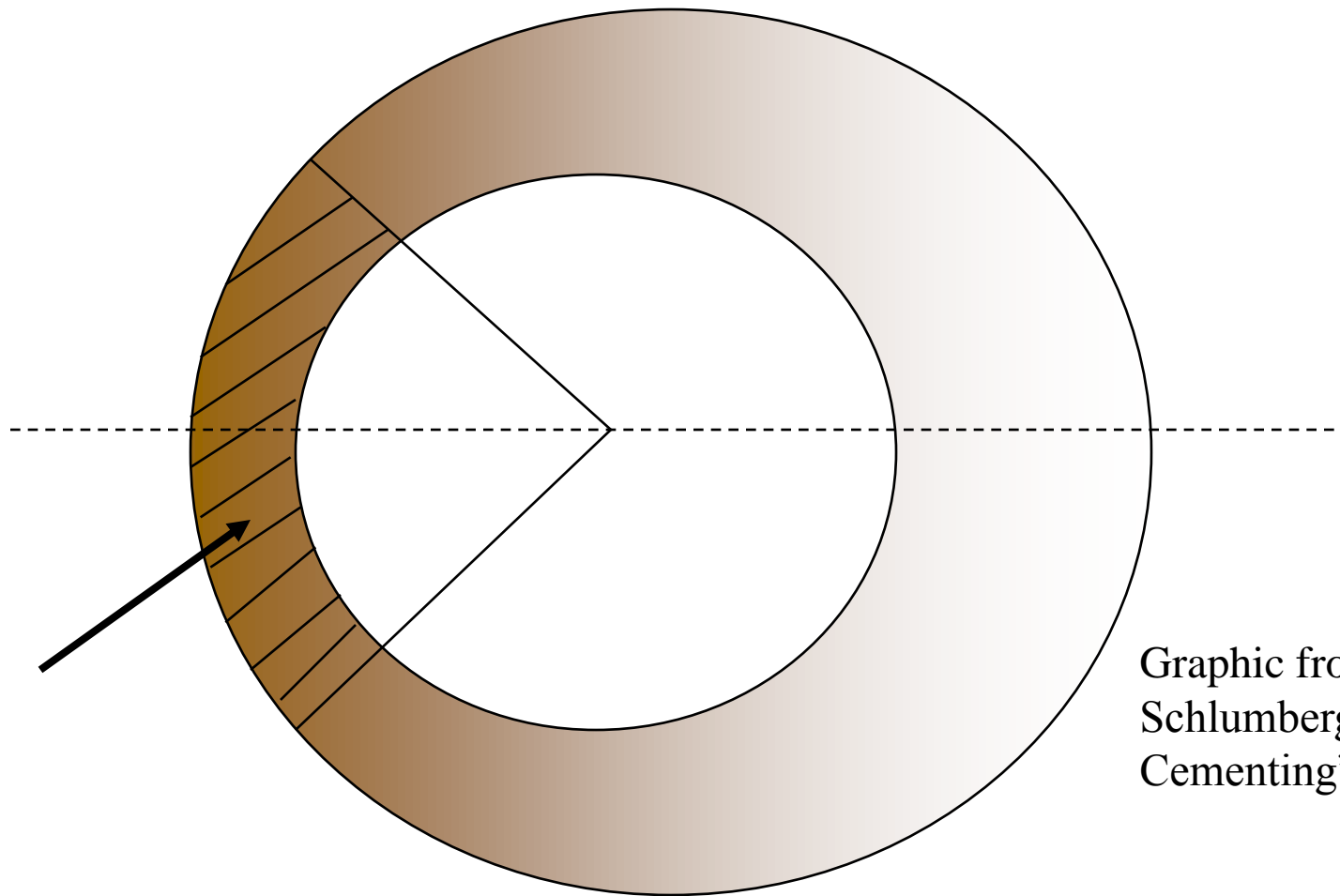


After 8 Minutes Rating 1



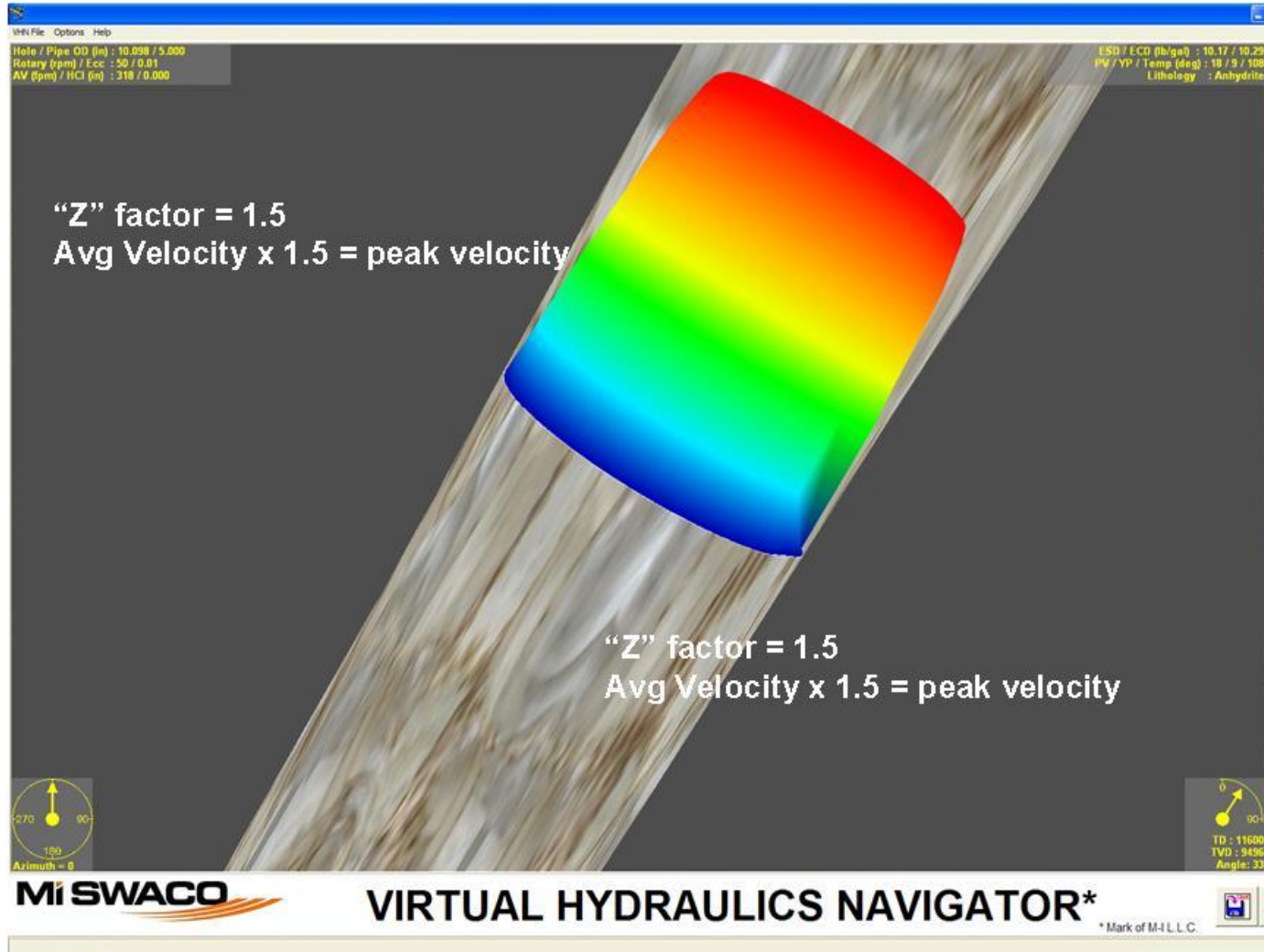
After 10 Minutes Rating 1

Use Spacer Density to Avoid Mud-Bypass in Eccentricity

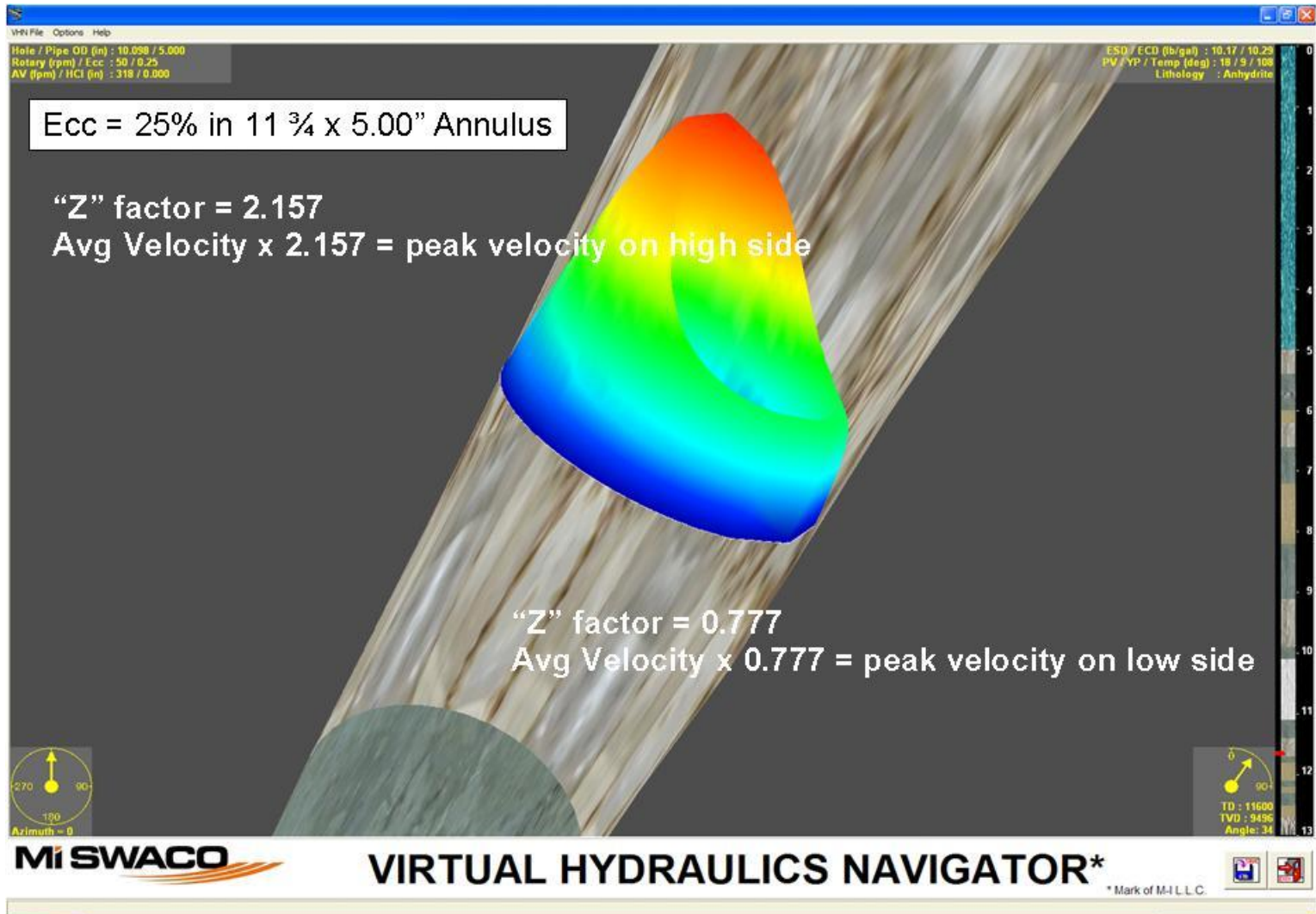


Graphic from
Schlumberger's "Well
Cementing"

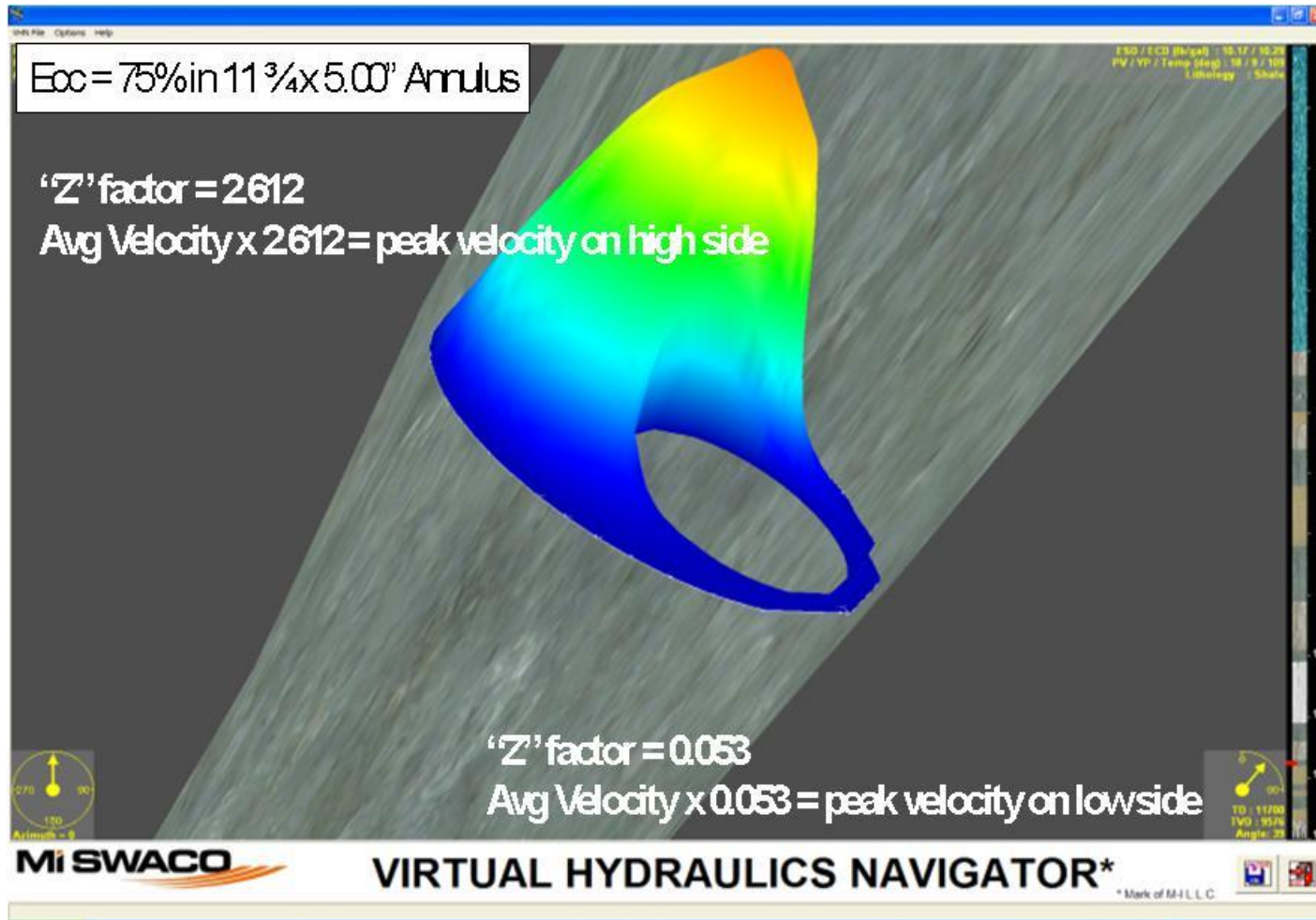
Cleaning Spacer Design



Cleaning Spacer Design

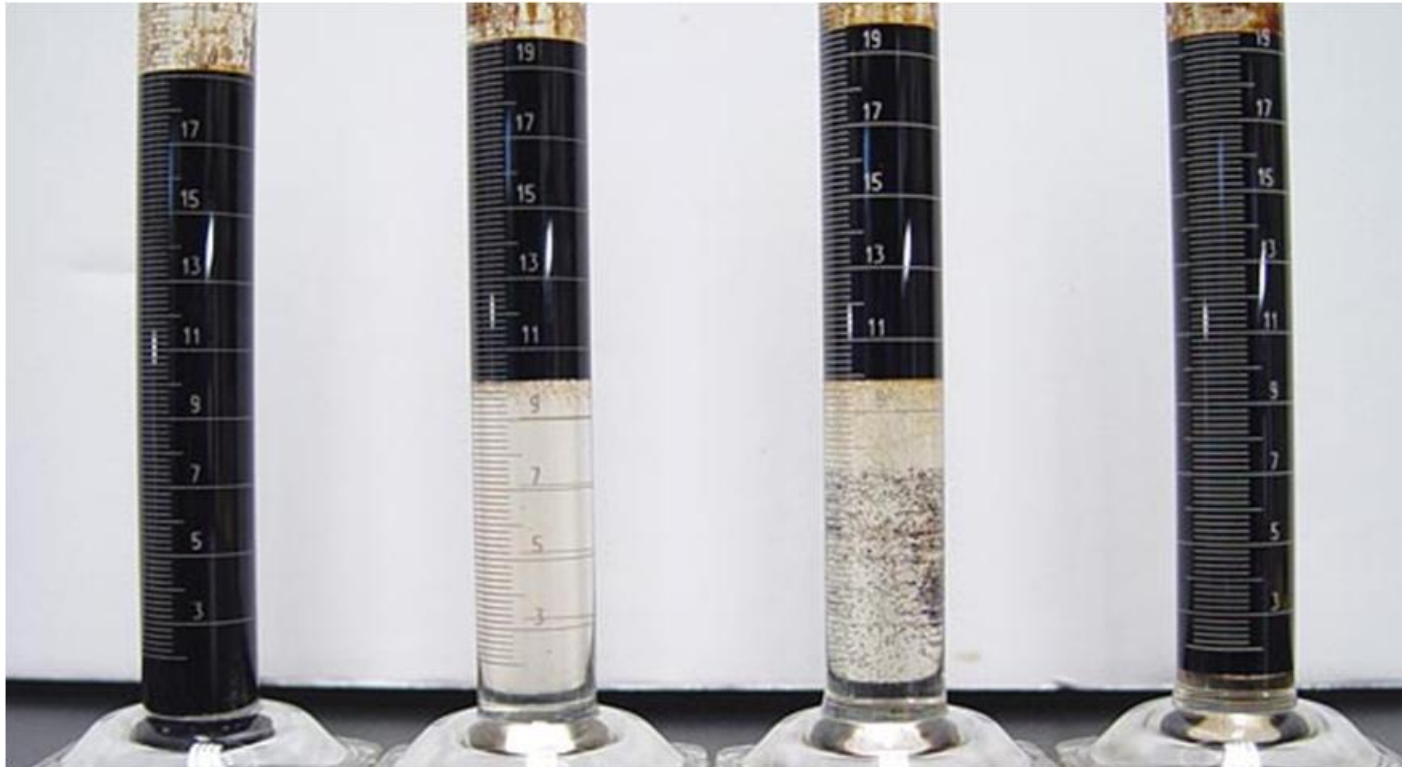


Cleaning Spacer Design



Fluid Compatibility

- Crude Compatibility



Fluid Compatibility

- Control Line Fluid



100%
Brine*

90%
Brine*

75%
Brine*

50%
Brine*

25%
Brine*

10%
Brine*

100%
Transaqua
HT

* 14.1 lb/gal CaBr₂ + 0.5vol% Safe-Break CBF + 0.1 vol% EGMBE

15 January 2009

Fluid Compatibility

- Frac Fluids



Questions?