"Completion Fluids Displacement & Cementing Spacers"

AADE FLUIDS MANAGEMENT GROUP
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Ed Robinson

Spacer Objectives

COMPLETION FLUID	CEMENTING
Minimize fluid contamination	Minimize cement contamination
Denser than fluid in hole	• Rheology Hierarchy
• Minimize channeling	• Minimize channeling
• Minimize contamination	• Compressive strength
Complete removal of drilling fluid	Erodability – congealed/dehydrated mud
Clean and condition tubulars	Condition the formation – water wetting
Density requirement – cased hole	Density Hierarchy – open hole
Compatibility	Compatibility

MANAGING INTERFACES

Typical Spacer Train – Completion Fluid

OBM/SOBM Drilling Fluid Displacement

- Base Oil ← **Cased Hole**
- Barrier Spacer
- Cleaning Spacer(s)

} **Cementing**

- Viscosified Spacer ← **Solids-free**
- Brine

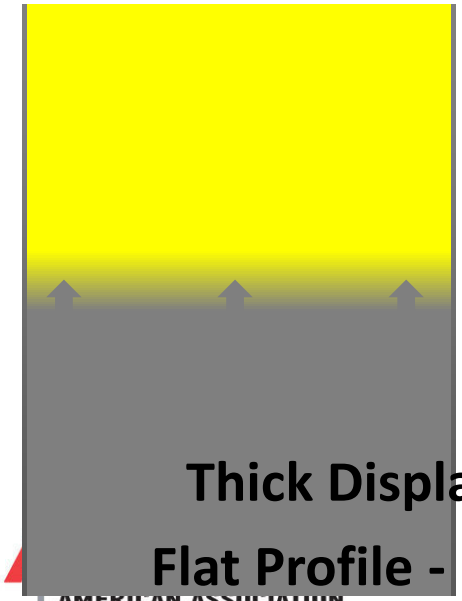
Increased Interest In Weighted Displacement

Spacer Heirarchies

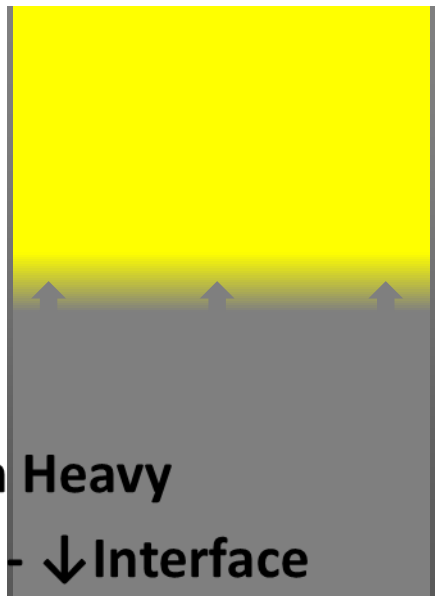
Base Oil Displacing Mud
High Interface

Thin Displacing Thick
Channels Into - ↑Interface

Heavy on Light
Differential Swap - ↑Interface



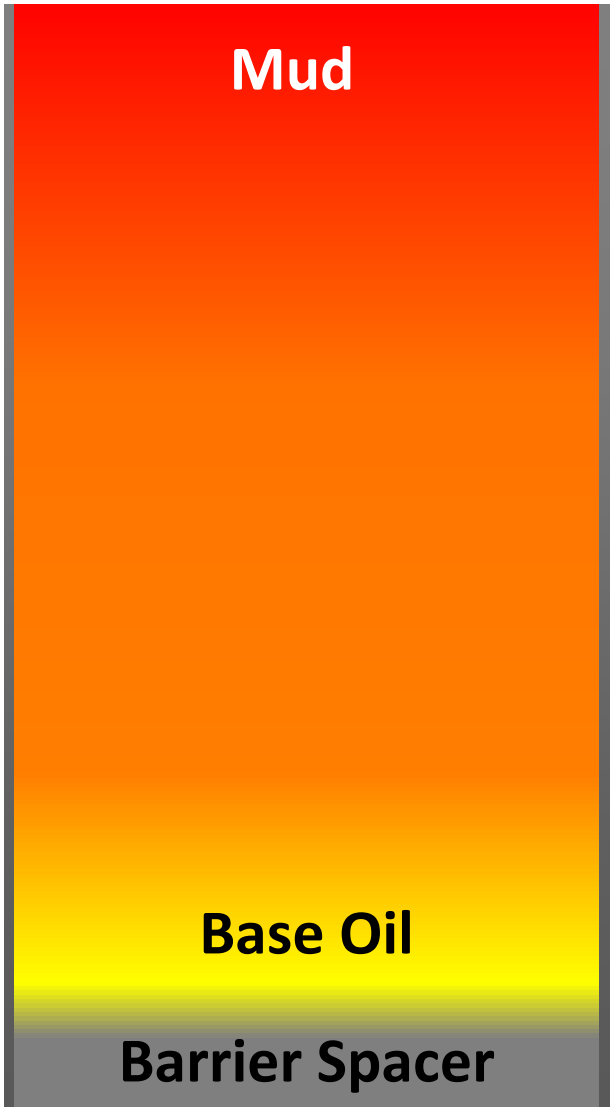
Barrier Displacing Base Oil
Tight Interface



Thick Displacing Thin
Flat Profile - ↓Interface

Light on Heavy
Floats on top - ↓Interface

Base Oil Interface



Density	Viscosity
+	+
-	-

Base Oil Problematic For Weighted Displacement

Barrier Spacer Against Mud

- **Rheology and density can be engineered greater than mud**
- **New surfactant packages achieve cleaning in Barrier Spacer**
- **13.0 lb/gal Barrier Spacer applied to 12.0 lb/gal SOBM**

Barite/XCD Barrier Spacer
200 rpm – 90 second

Barite/XCD Surfactant Package
200 rpm – 90 second

Barrier Spacer

- **Cleaning efficiency typically >97%**

Dry – clean

Mud coated

30 second

120 second

Barite Weighted Surfactant Package
200 rpm – Equivalent to 84 ft/min AV

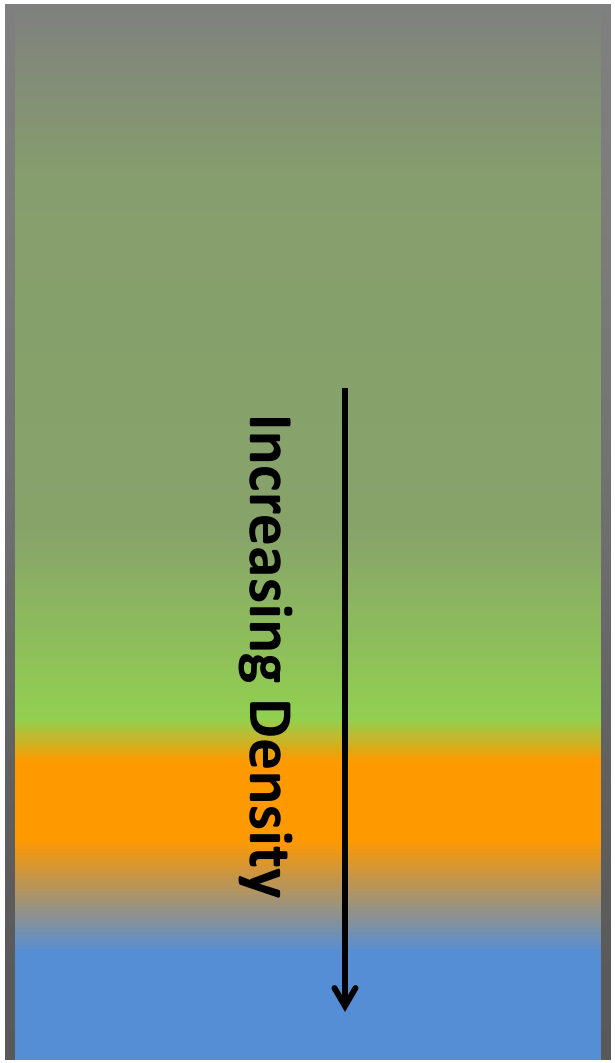
Barrier Spacer Against OBM/SOBM

- **Compatibility**

Property	#1	#2	#3	#4	#5
Barrier Spacer	100%	75%	50%	25%	0%
SOBM	0%	25%	50%	75%	100%
600	80	89	75	74	80
300	75	62	48	43	54
200	64	48	37	32	44
100	42	33	25	18	32
6	13	9	8	7	13
3	11	7	7	5	12
PV	5	27	27	31	26
YP	70	35	21	12	28

13.0 lb/gal Barrier Spacer / 12.0 lb/gal SOBM

From Denser DF to Brine



Cleaning Spacer

- **Compatible and functional in interface with Barrier Spacer**
- **Functional in weighted brine base**
- **Water wetting**

Do not over-thicken Vicosified Spacer

-	+
Density	**Viscosity**
+	-

Barrier/Cleaning Spacer Interface

- **What is the expected interface?**
- **Compatible and functional through heavy interface?**

Mud Film

50-50 Barrier/Cleaning

Dried

12.0 SOBM - 50%vol 13.0 lb/gal Barrier-50%vol 10.9 lb/gal Cleaning – 97.9% Removal

Managing Interfaces

- Cementing typically applies a strict regime from **thinner to thicker** and **lighter to heavier**
- Spacer system management
  - Testing should include interfaces
    - DF contaminated Barrier
    - Barrier into SOBM LC-50
    - Barrier contaminated Cleaning
  - Fully weighted systems
  - Dual function spacer - Barrier as Primary Cleaner

Operational Execution - Cementing

- Mud Condition
- Mud static exposure to formation
- Eccentricity (stand-off)
- Spacer properties downhole
- Do not start and stop pumps

Static Time - Cementing

12 ppg mud, 16.8 ppg cement, 7 BPM flow rate

Static Time	Efficiency
None	98
5 minutes	83
2 hours	62
4 hours	50

Efficiency is defined as % of annulur cross section containing cement

Pipe Movement - Cementing

16.7 ppg mud, 16.7 ppg cement, 7 BPM flow rate

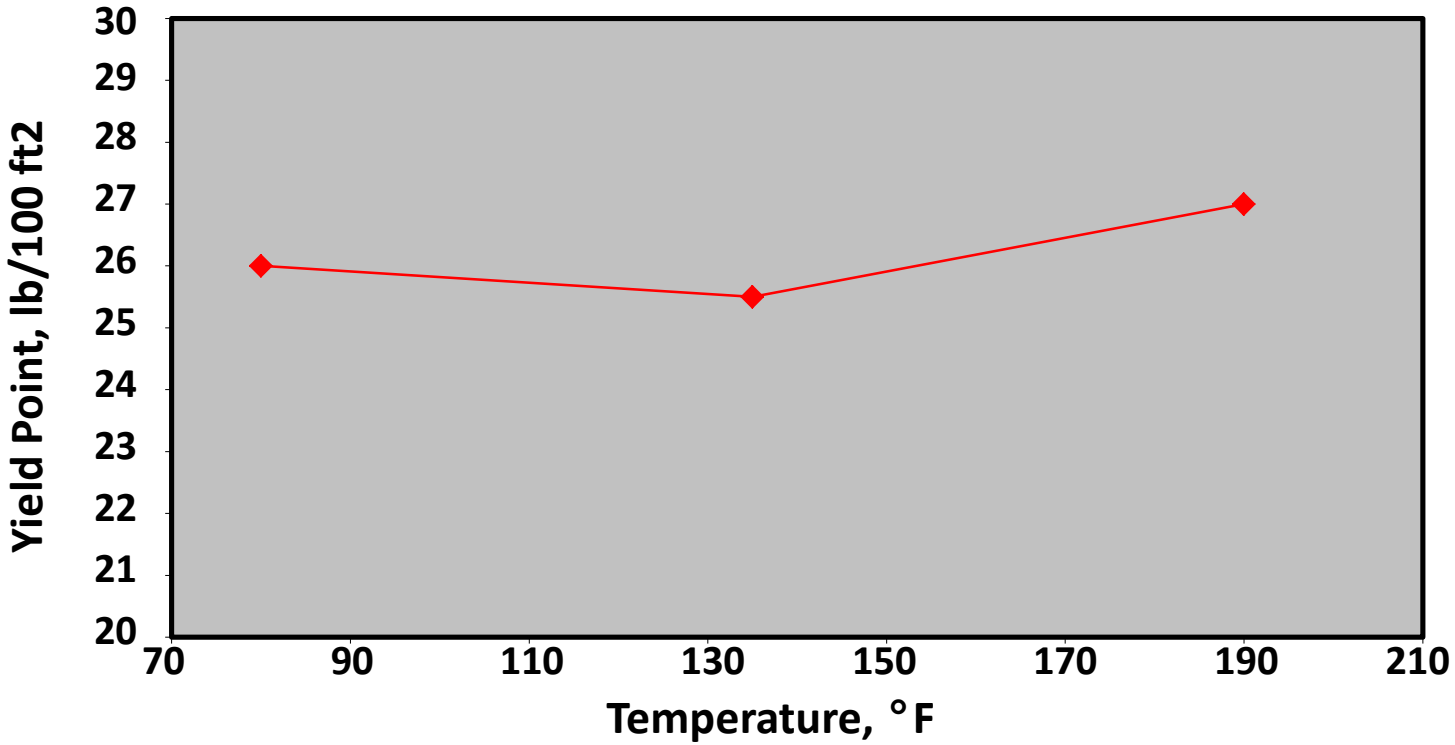
Standoff	Efficiency
17%	45
35%	77
60%	88
72%	97

16.7 ppg mud, 16.7 ppg cement, 4 BPM flow rate, 60% standoff

Movement	Efficiency
None	65
20 RPM	97

Efficiency is defined as % of annulur cross section containing cement

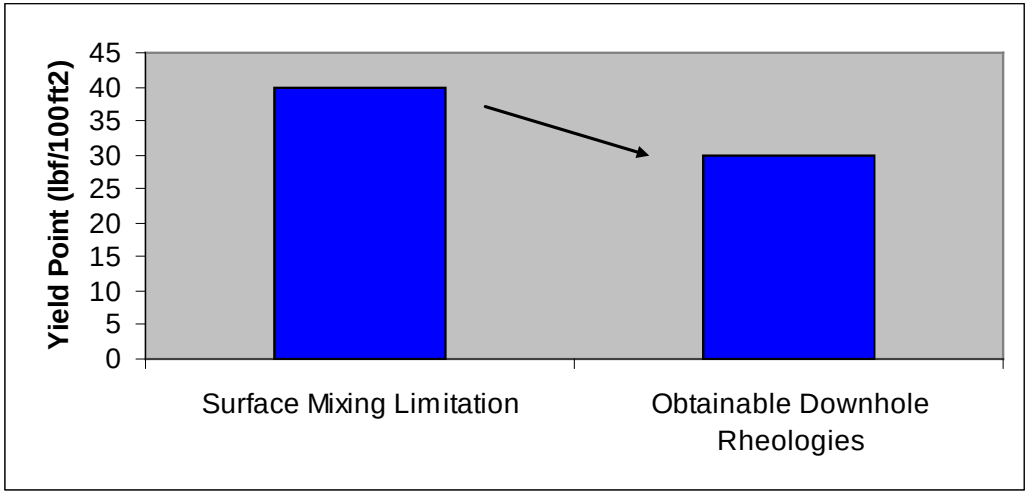
Downhole Delivery - Cementing

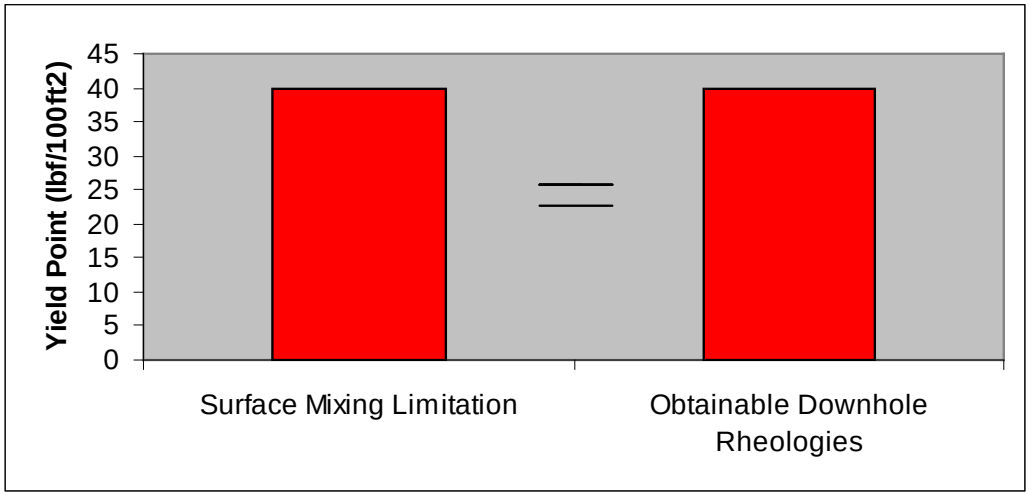


- For Erodability and Rheology Hierarchy
  - Critical to deliver consistent rheology downhole
  - Flat rheology across temperature profile

Cement Spacer Reliability

- Rheologically Enhanced
  - Eliminate guess or estimate of effective YP
  - Deliver what is measured on surface





Other Considerations

- Compatibility testing
- Wettability testing (conductivity)
- Cleaning efficiency
- Spacer criteria
  - Separation distance (interval of spacer - feet)
  - Contact time (minute)
  - Surface area (or mud residue volume)
- Limitations – Rig equipment, environmental, etc.
  - Risk analysis
  - Engage all stakeholders

Questions