New Approach in Wellbore Strengthening to Eliminate a Casing String

SHARP-ROCK TECHNOLOGIES, INC.

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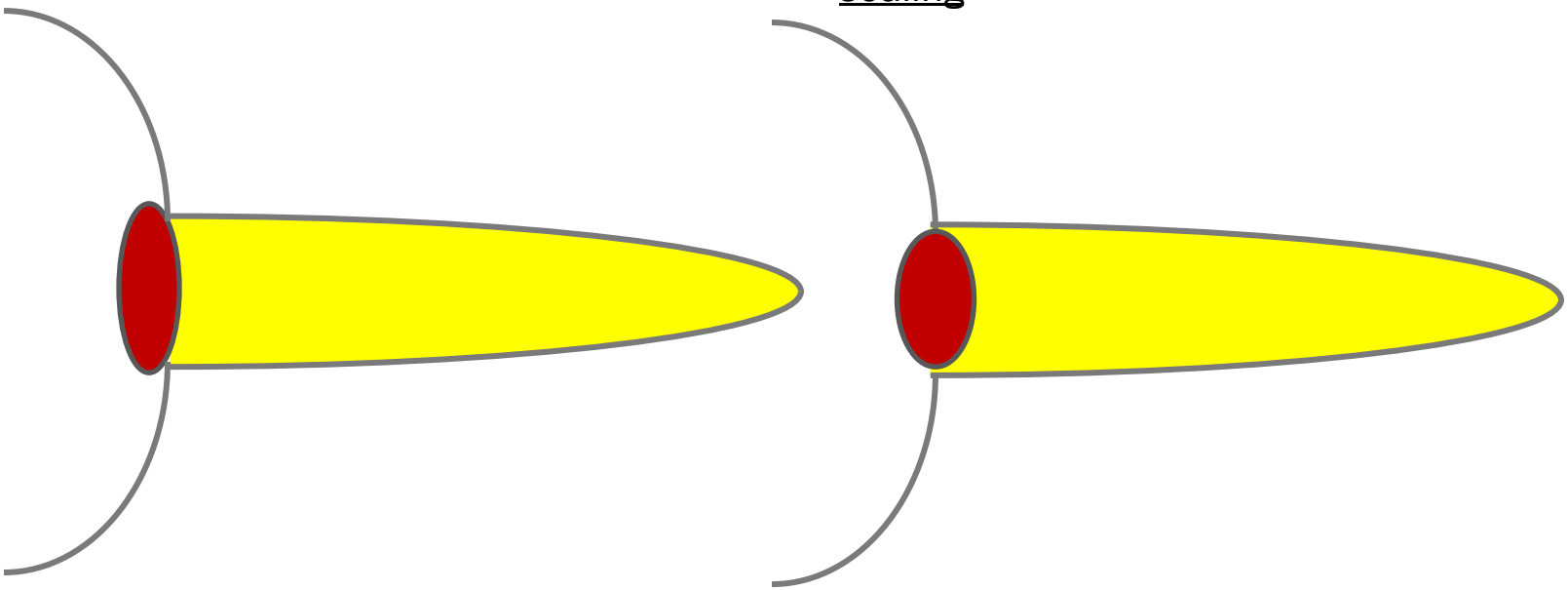
Some Conclusions from the Simulation Study

Fracture sealing without propping can strengthen a wellbore (IPTC-12280)

Fracture propping without sealing can NOT strengthen a wellbore (SPE 112629)

- It can only when it is together with sealing



So sealing, NOT propping, a fracture is essential to wellbore strengthening!

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Reality Check - What is Feasible?

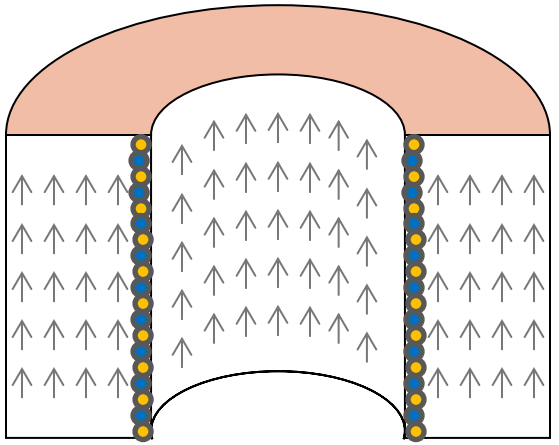
Numerous lab tests indicate sealing without propping a fracture is very feasible

No lab tests observed indicate propping a fracture at the entrance is feasible

Sealing without propping at the Entrance

GPRI 2000

Propping at the Entrance



So fracture sealing is feasible for wellbore strengthening!

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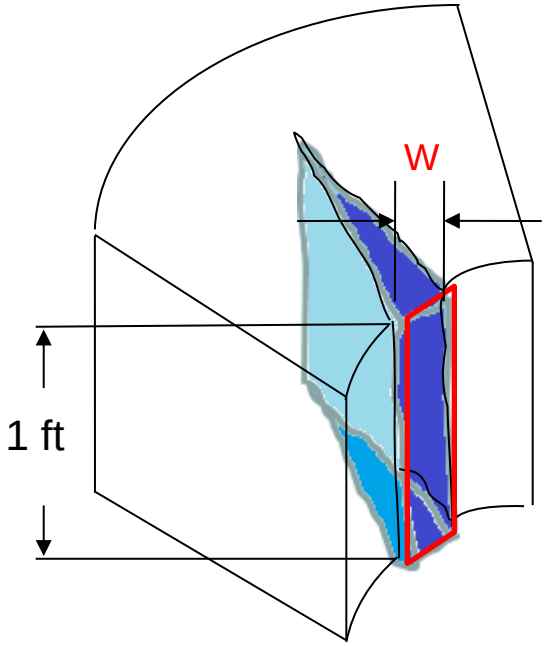
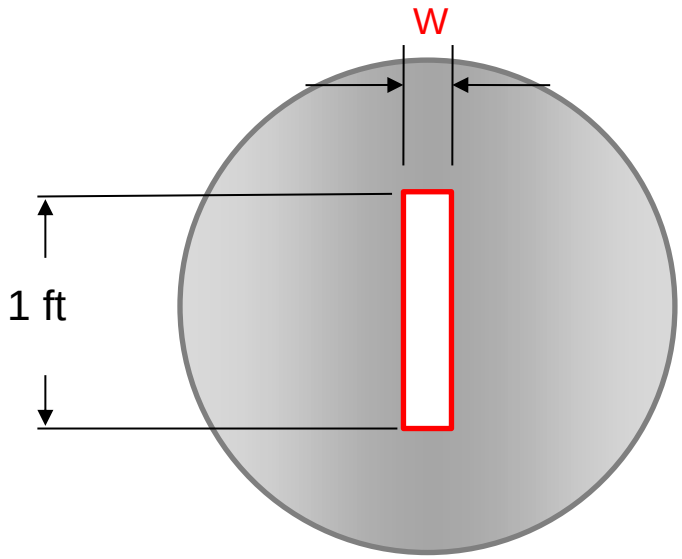
Fracture Entrance Simulated with Slot Discs

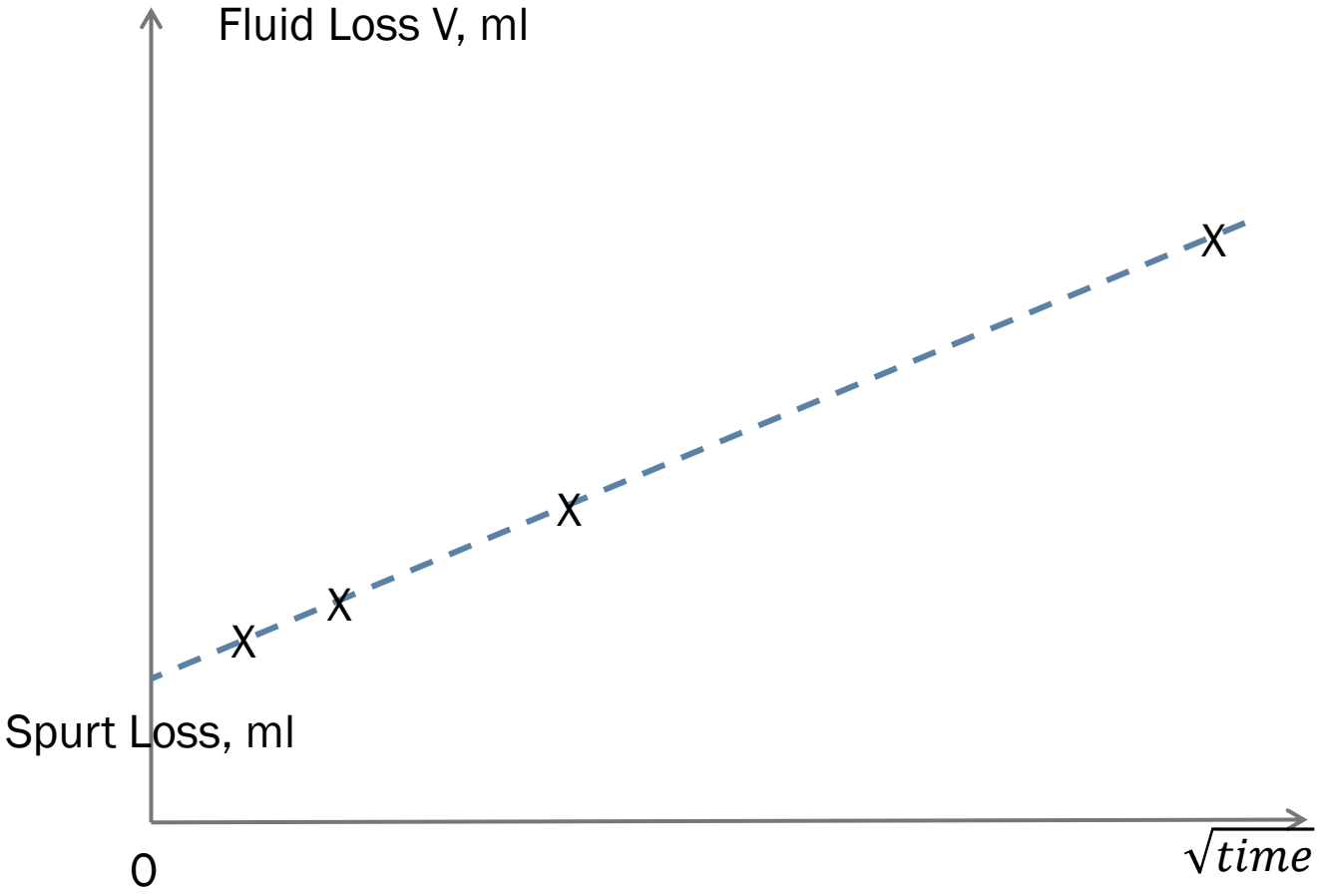


slot disc

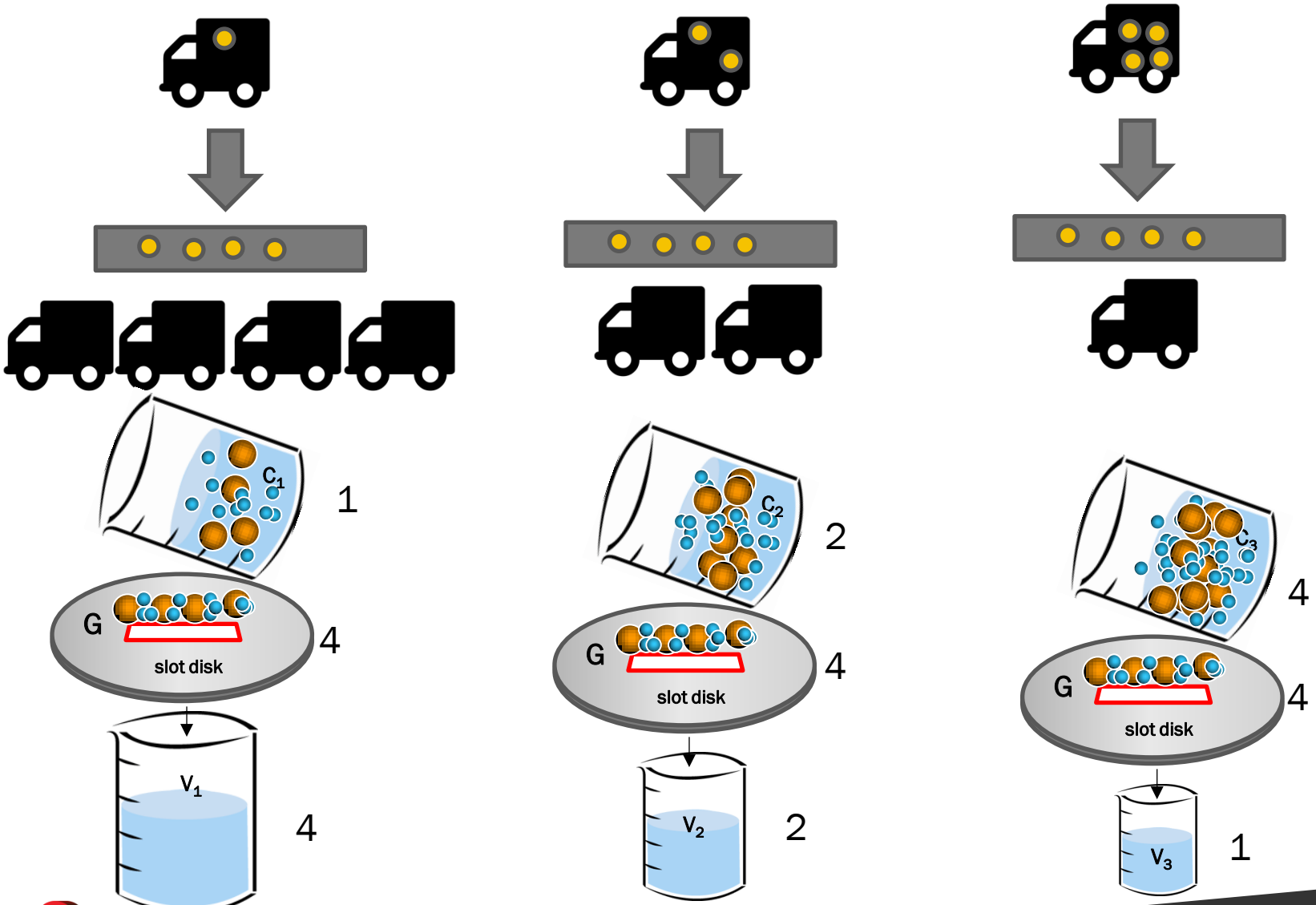


W = Sealing Width

Quantify Sealing with Spurt



Sealing Weight G = $C_1V_1 = C_2V_2 = C_3V_3 = 4$ = Constant



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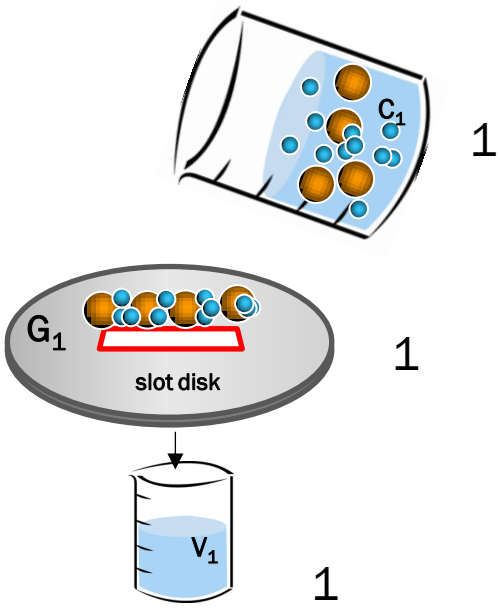
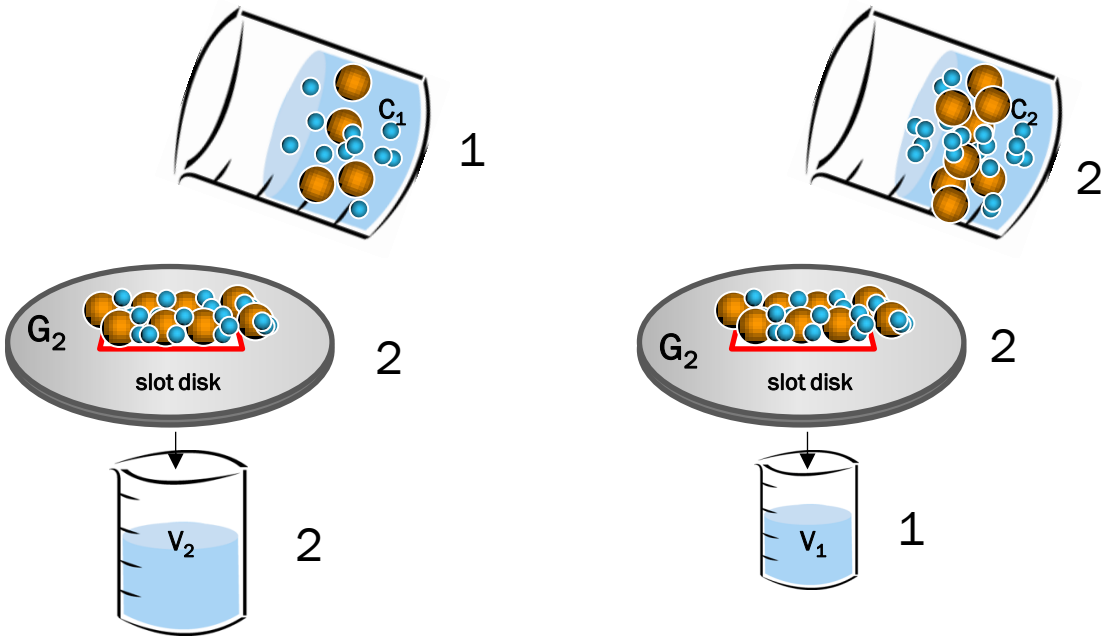
Sealing Performance Comparison

Sealing Weight G = CV

Proudct1 (W, G_1 = 1)



Product2 (W, G_2 = 2) (half efficient)



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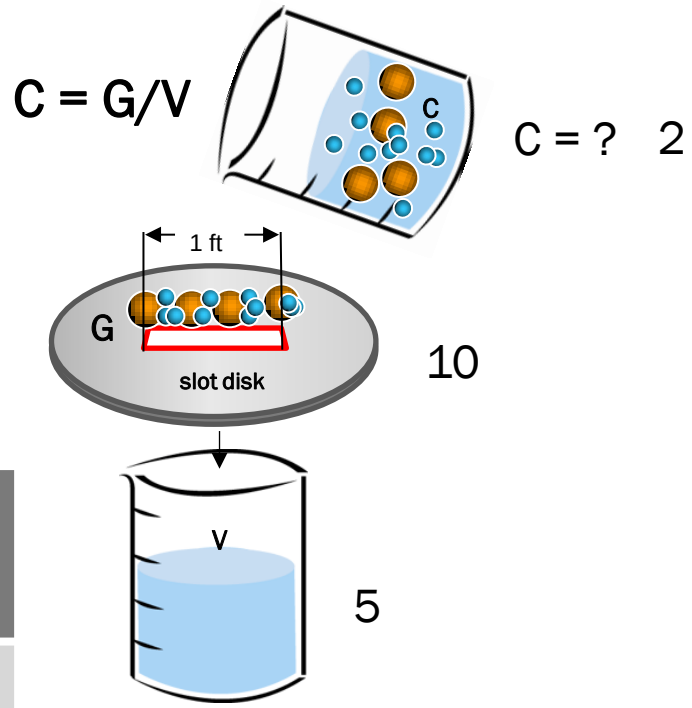
Achieve a Desired Spurt Control (Volume) Easily with Performance LCM (W,G)

When G is known, for a desired spurt V,
C = G/V = 10/5



Preventive Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft	Shaker Screens
Seal to Stop (fine)	200	0.1	API 60 mesh
Seal to Stop (medium)	500	?	API 40 mesh
Seal to Stop (coarse)	850	?	API 18 mesh

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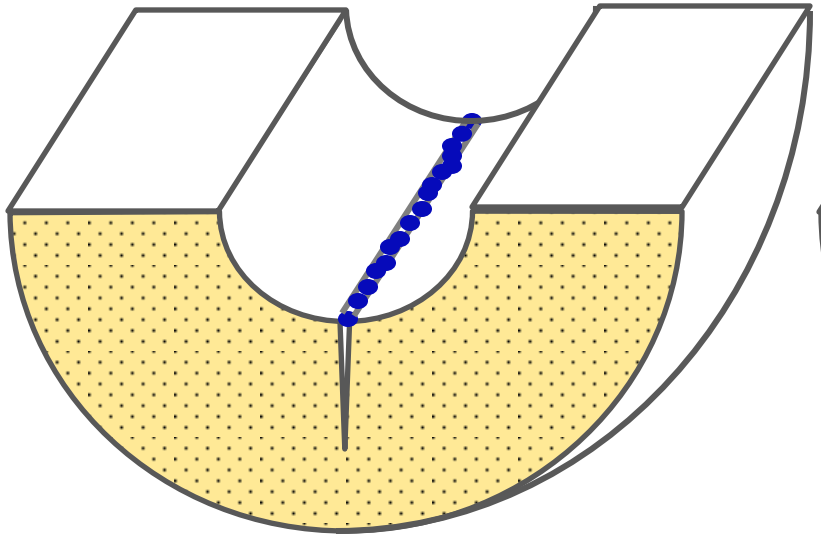
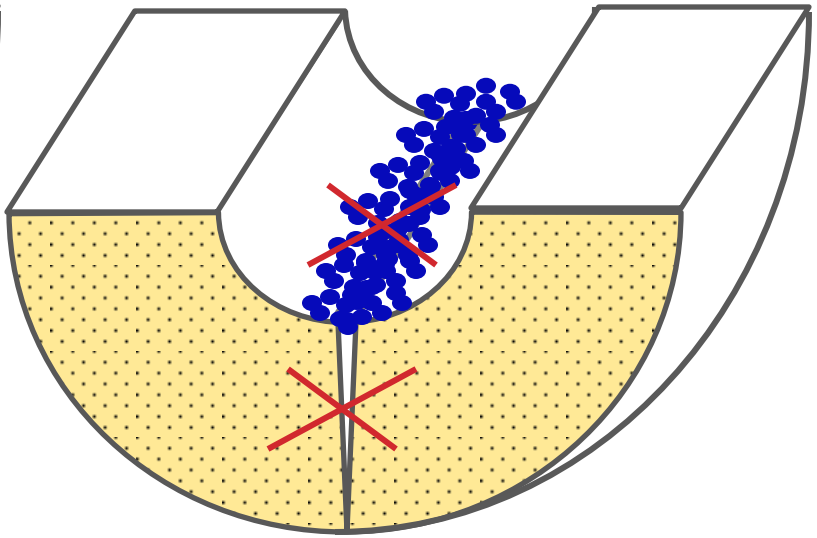
SEALING WEIGHT G AND SEALING – NOT ONLY JUST SPURT

Performance LCM

Conventional LCM
if Sealing





Low efficiency
with side effects

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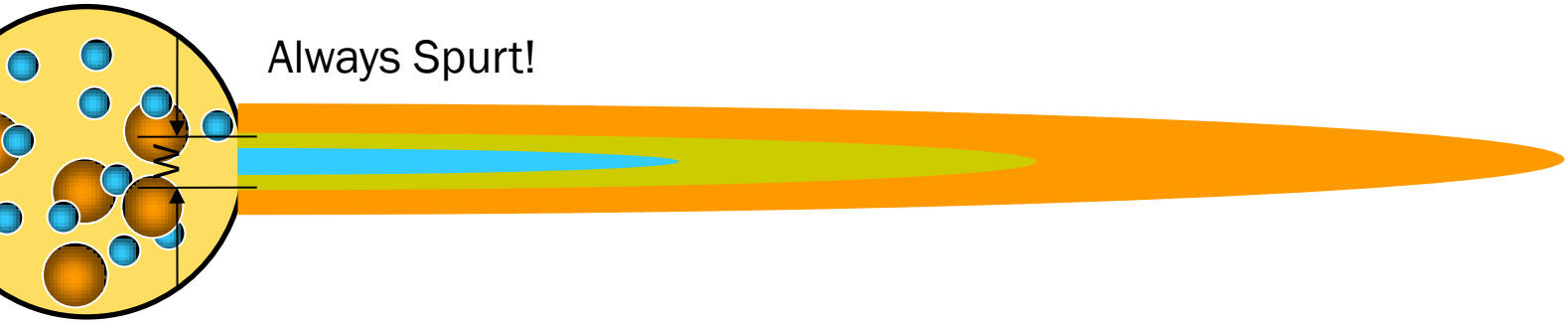
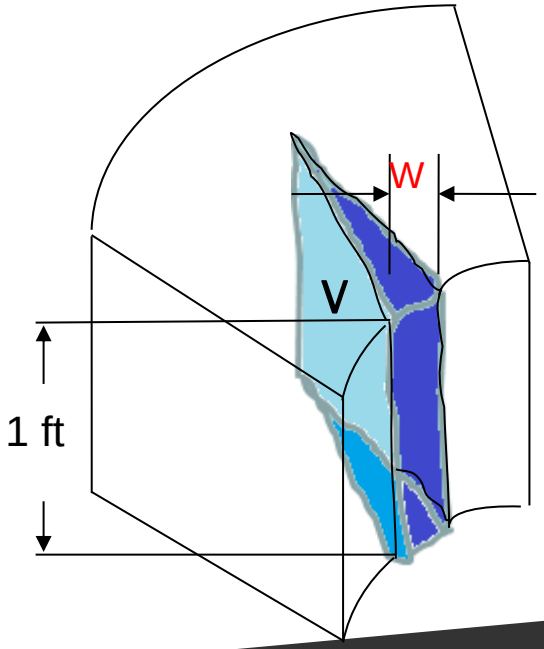
Hydraulic Fracturing, Calculation, Spurt



Formation Depth, ft	8000	8000	8000
Wellbore Pressure, ppg	10.5	10.5	10.5
FG, ppg	9.0	9.0	9.0
Young's Modulus, 10^6 psi	2.5	2.5	2.5
Poisson's Ratio	0.13	0.13	0.13
Hole Diameter, inch	8.5	8.5	8.5
Width, micron	200	350	500
Fracture Length, inch	8.5	10.4	16.3
Fracture Volume, ml/ft	9.5	20.5	46.4



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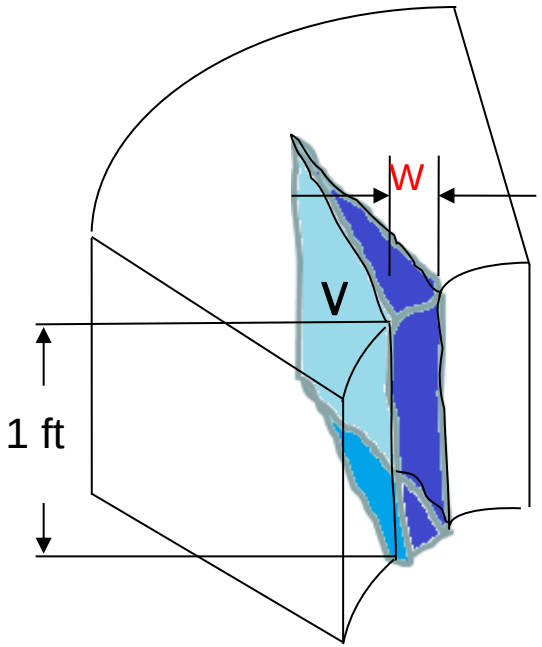
Define How Much Spurt Can be Tolerated When the Same Width Reached – Wellbore Pressure

Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft
Seal to Stop fine	200	0.1

Formation Depth, ft	8000	8000	8000
Wellbore Pressure, ppg	10.0	10.5	11.0
FG, ppg	9.0	9.0	9.0
Young's Modulus, 10^6 psi	2.5	2.5	2.5
Poisson's Ratio	0.13	0.13	0.13
Hole Diameter, inch	8.5	8.5	8.5
Width, micron	200	200	200
Fracture Length, inch	8.5	4.8	3.1
Fracture Volume, ml/ft	9.5	5.3	3.3



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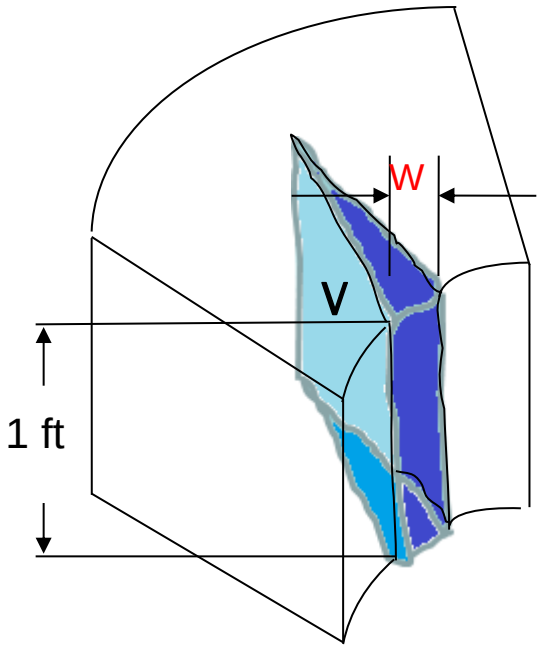
Define How Much Spurt Can be Tolerated When the Same Width Reached – Young's Modulus

Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft
Seal to Stop fine	200	0.1

Formation Depth, ft	8000	8000	8000
Wellbore Pressure, ppg	10.5	10.5	10.5
FG, ppg	9.0	9.0	9.0
Young's Modulus, 10^6 psi	2.5	3	4
Poisson's Ratio	0.13	0.13	0.13
Hole Diameter, inch	8.5	8.5	8.5
Sealing Width, micron	200	200	200
Fracture Length, inch	4.8	6.3	9.3
Fracture Volume, ml/ft	5.3	6.9	10.4



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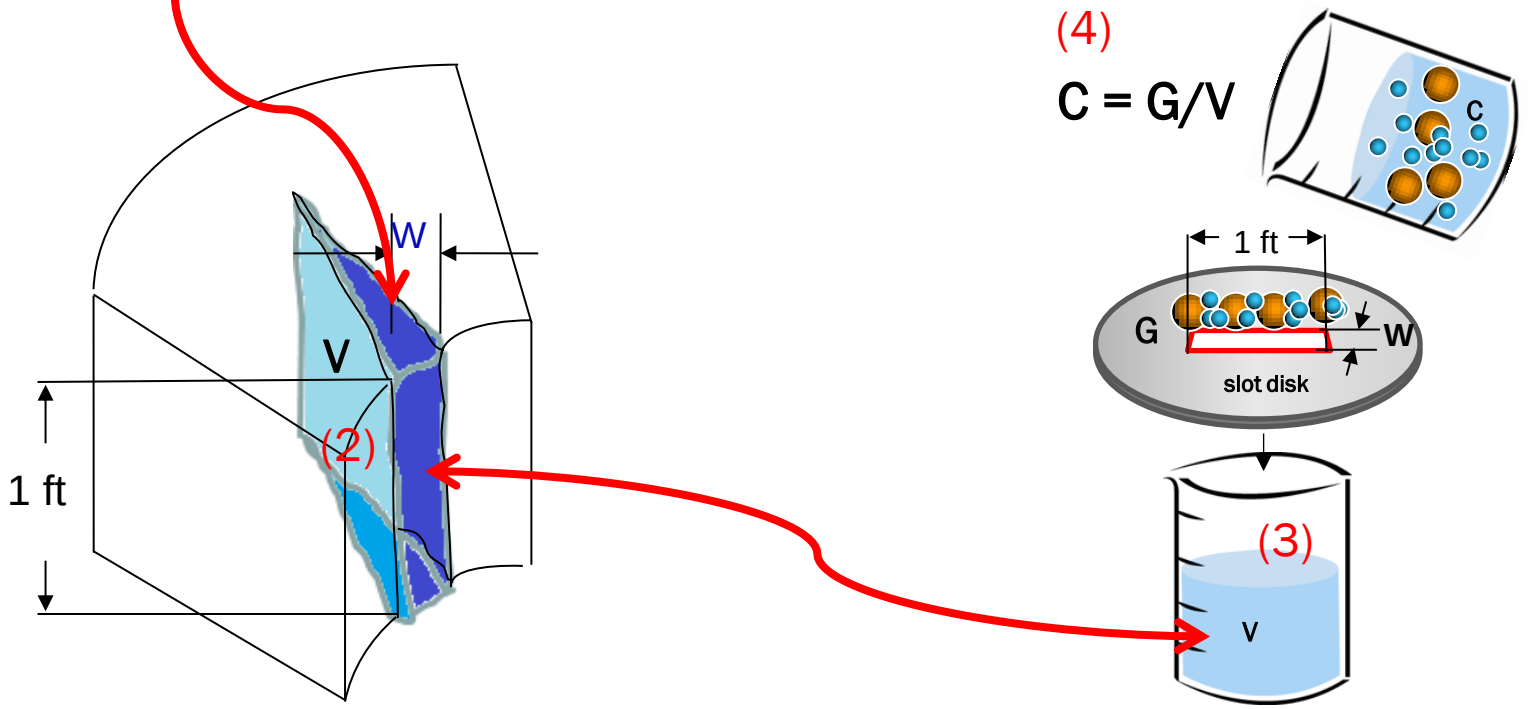
Seal2Strengthen Engineering Method for Wellbore Strengthening (patent pending)

Preventive Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft	Shaker Screens
Seal to Stop fine	(1) 200	0.1	API 60 mesh



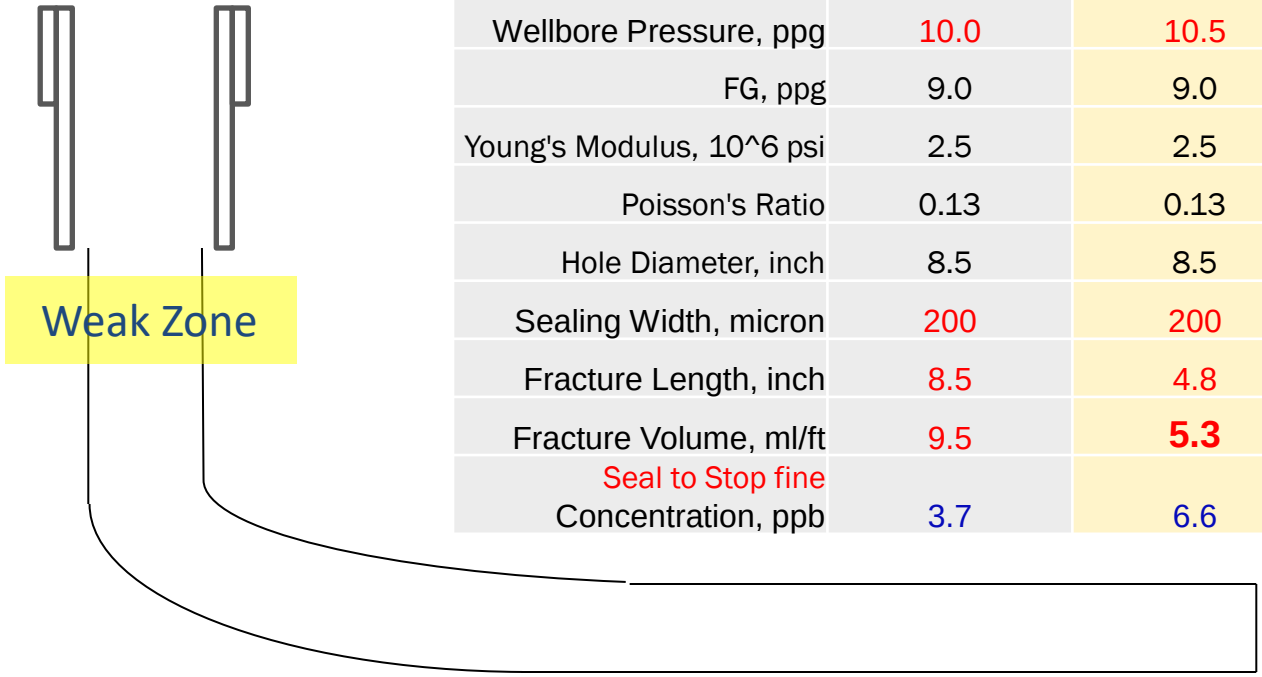
Seal2Strengthen to Eliminate Casing

Weak Zone:

- Depth – 8000’ TVD
- FG – 0.468/ft or 9.0 ppg equiv. (depletion)
- Max ECD (target strength) – 10.5 ppg equiv.
- YM – 2.5 M to 4 M
- PR – 0.13 to 0.18
- Hole Size – 8.5”

C = G/V
= 0.1g/ft/5.3 ml/ft
= 6.6 ppb

Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft
Seal to Stop fine	200	0.1



Formation Depth, ft	8000	8000	8000
Wellbore Pressure, ppg	10.0	10.5	11.0
FG, ppg	9.0	9.0	9.0
Young's Modulus, 10^6 psi	2.5	2.5	2.5
Poisson's Ratio	0.13	0.13	0.13
Hole Diameter, inch	8.5	8.5	8.5
Sealing Width, micron	200	200	200
Fracture Length, inch	8.5	4.8	3.1
Fracture Volume, ml/ft	9.5	**5.3**	3.3
Seal to Stop fine Concentration, ppb	3.7	6.6	10.5

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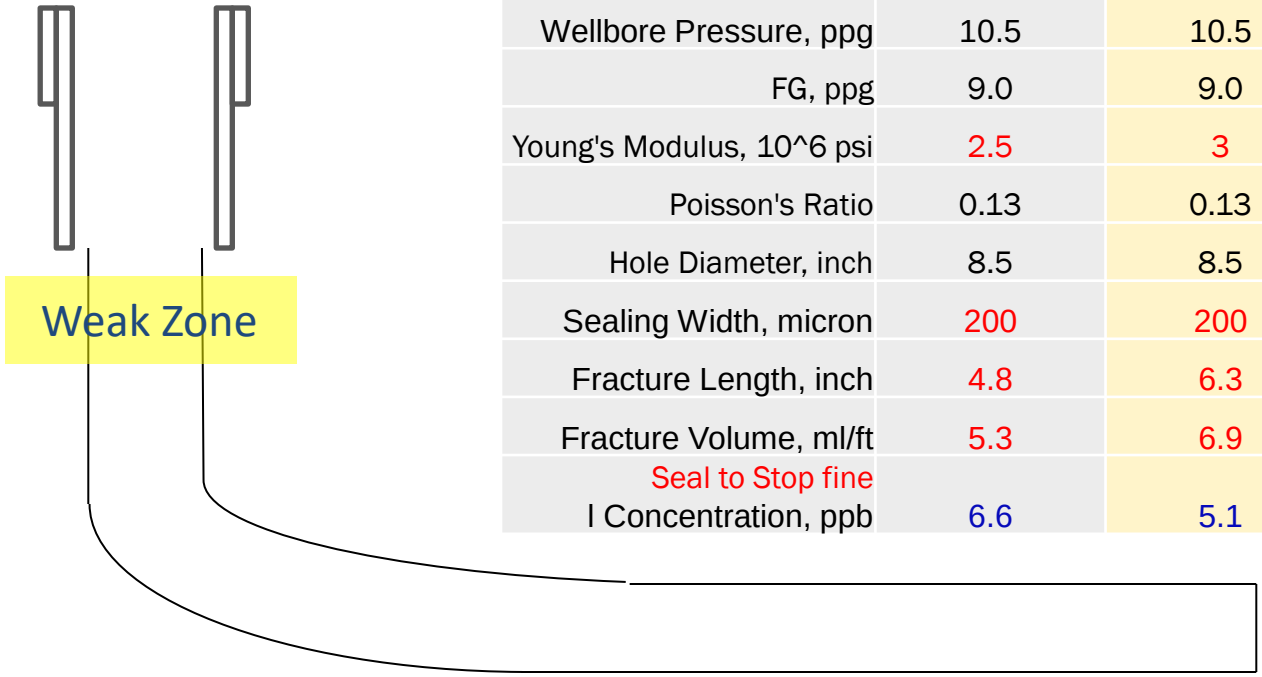
Seal2Strengthen Enables Design with Uncertainties

Weak Zone:

- Depth – 8000’ TVD
- FG – 0.468/ft or 9.0 ppg equiv. (depletion)
- Max ECD (target strength) – 10.5 ppg equiv.
- YM – 2.5 M to 4 M
- PR – 0.13 to 0.18
- Hole Size – 8.5”



Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft
Seal to Stop fine	200	0.1

Formation Depth, ft	8000	8000	8000
Wellbore Pressure, ppg	10.5	10.5	10.5
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Young's Modulus, 10^6 psi	2.5	3	4
Poisson's Ratio	0.13	0.13	0.13
Hole Diameter, inch	8.5	8.5	8.5
Sealing Width, micron	200	200	200
Fracture Length, inch	4.8	6.3	9.3
Fracture Volume, ml/ft	5.3	6.9	10.4
Seal to Stop fine l Concentration, ppb	6.6	5.1	3.4

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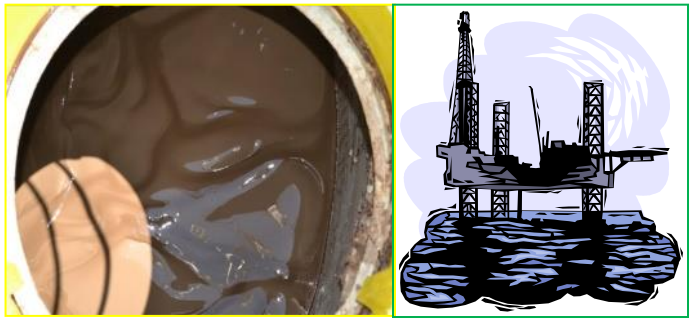
Rigsite Application and Maintenance

Performance Quantified with defined W and G

Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft
Seal to Stop fine	200	0.1

1. Add product to active mud at the concentration C+ and maintain C+ while drilling (with a safety factor)



2. Direct Measure: Rigsite Spurt Loss Test for V, then calculate C

V = 7.0 ml/ft

C = G/V
= 0.1g/ft/7.0 ml/ft
= 5.0 ppb

So 1.6+ ppb more is needed.

Formation Depth, ft	8000
Wellbore Pressure, ppg	10.5
FG, ppg	9.0
Young's Modulus, 10^6 psi	2.5
Poisson's Ratio	0.13
Hole Diameter, inch	8.5
Sealing Width, micron	200
Fracture Length, inch	4.8
Fracture Volume, ml/ft	5.3
Seal to Stop fine **Conc., ppb**	**6.6**

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Summary

Fracture sealing is the key to strengthen a wellbore

- Simulation shows sealing is essential to wellbore strengthening, not propping
- No lab observation of particles lining up at a fracture entrance supporting fracture propping

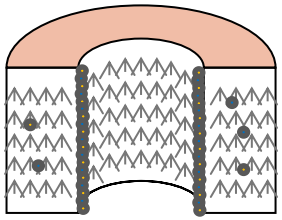
Quantified sealing with preventive performance LCM

- The fracture sealing performance of an LCM is quantified with sealing width W and sealing weight G
- Concentration of performance LCM is used to directly control spurt volume. Given a desired V, C can be calculated based on C = G/V

Desired spurt control is limited by fracture volume V at the sealing width W

- For a specific drilling project, define the fracture volume V
- Then minimum LCM concentration C is calculated based on C = G/V

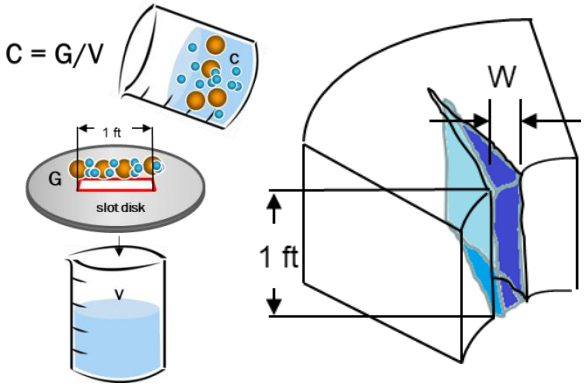
Rigsite QC is to directly test spurt loss V to calculate concentration C to know if it is enough and how much of additional LCM needed if not



G = CV

Performance LCM	Sealing Width W, micron	Sealing Weight G, g/ft
Seal to Stop fine	200	0.1

Seal2Strengthen



Minimum Concentration = G/V

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THANK YOU!

SHARP-ROCK
Performance LCM Provider

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