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Cementing Paradigm Shift: A Local Solution to a Global Problem

SPE
International

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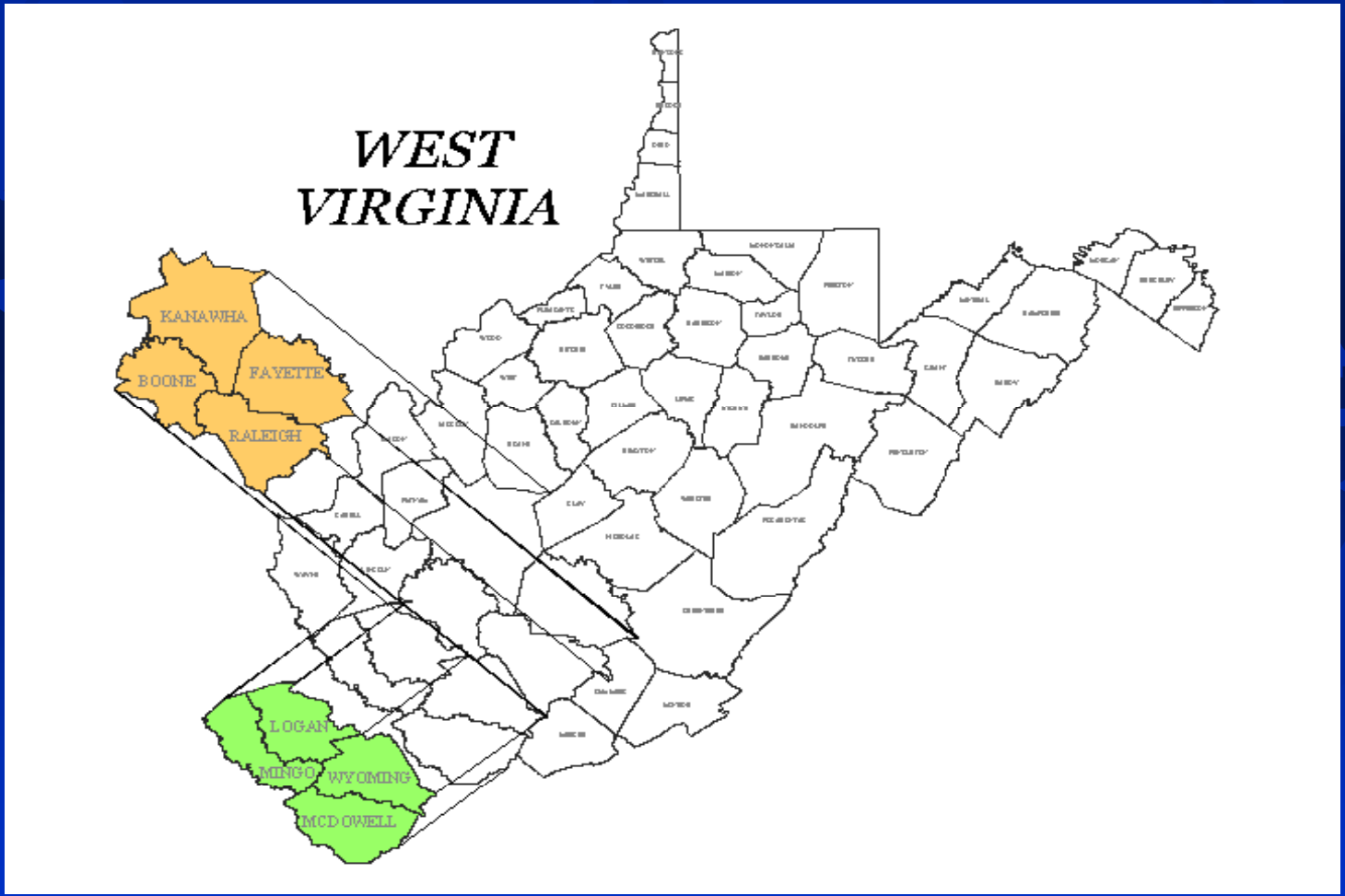
Outline

- Introduction
- Cement strength requirements
- Solving a consequential problem
- Lab workup
- Field examples
- Economics
- Conclusions

Introduction

Area of Interest



Introduction

Cement Job Objectives

- Cement across low frac gradient shales
- Provide zonal isolation for multiple pay zones
- Stand up to stresses incurred during hydraulic fracturing
- Economical

Introduction

History of Gas Shale Well Cementing

- Two-stage jobs
- Thixotropic slurries
- Microspheres
- Foam
- Silicate-extended

Introduction

Lightweight Silicate-Based Cement

Original Lightweight Silicate Cement (80°F)		
Density (ppg)	Yield (ft^3/sk)	72-Hour Compressive Strength (psi)
11.5	**2.91**	**470**
12.0	**2.48**	**700**
12.5	**2.15**	**1,050**
13.0	**1.91**	**1,550**
13.5	**1.71**	**1,941**

Cement Strength Requirements

- Normally consider only unconfined compressive strength
- 2,000 to 5,000 psi is typical requirement
- Tensile and flexural strength also important
- 8 psi tensile strength required to support a casing string (equates to approximately 100 psi compressive strength)
- Cracking failures are all but eliminated with the use of low-density and low-compressive strength cement

Introduction

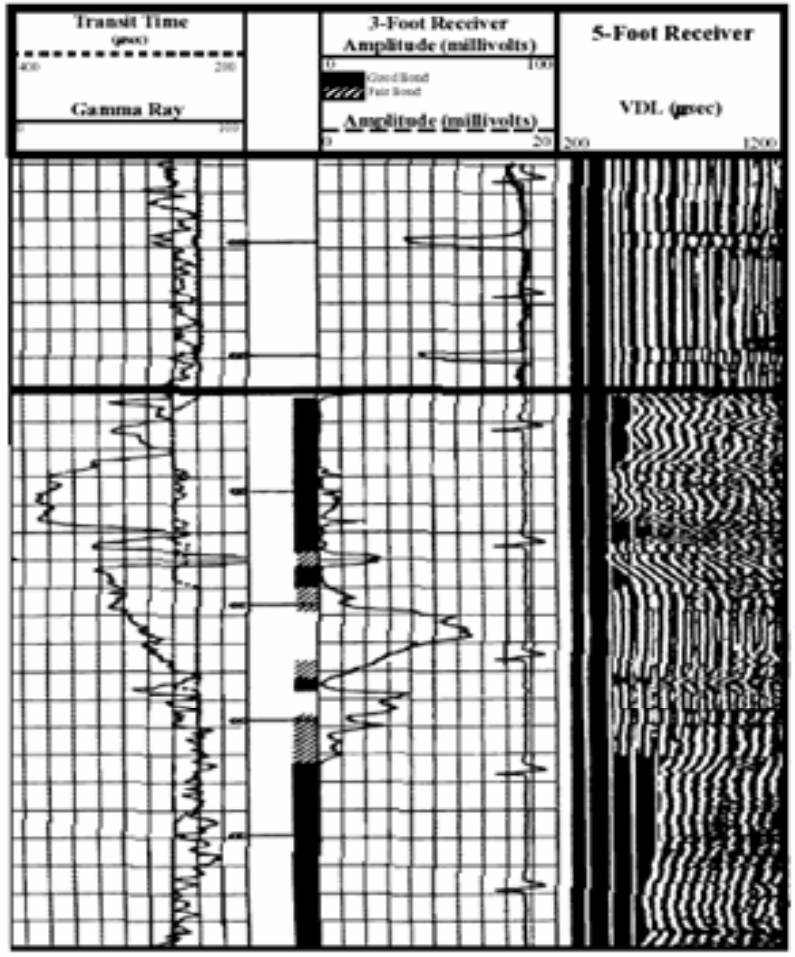
Lightweight Silicate-Based Cement

- 12 ppg density
- Cement 4,000 feet plus in single stage
- Very economical versus two-stage cement jobs and other cement blends
- Used on over 2000 wells since 1998

Consequential Problem

- The problem:
  - Cement sheath with 700 psi compressive strength can't be "seen" with conventional CBL logging equipment available in the Appalachian Basin
  - Longer waiting-on-cement time required for additional strength development
  - Result is several days of lost production per well

TYPICAL CEMENT BOND LOG



Free

Pipe

Channel - ?

Good
Bond

How Can We See The Cement?

- Compressive strength and acoustic attenuation relationship
  - Goal: 1,000 psi compressive strength should yield enough acoustic impedance to achieve attenuation

How Can We See The Cement?

Compressive strength and acoustic attenuation relationship.

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Lab Workup

Objectives For New Cement

- 1,000 psi compressive strength
- CBL must “see” it in 72 hours
- 12 ppg density
- Normal thickening time
- Easy to mix and pump

Lab Workup
Chemistry

- Compressive strength hurdle tough at first using Class A/Type I cement @ 12 ppg
- Pozzolan powder discovered to be effective at concentration up to 10%
- Changing portland cements to ASTM Type III cement played a large role in achieving compressive strength goal

Lab Workup

New Blend Slurry Properties

Lightweight Slurry Information								
Thickening Time (hrs:mins)			2:41	*Rheologies*				
Temperature (°F)			80	RPM	AMB	°F		°F
Ramp (hrs:mins)			:20	300	43			
Pressure (psi)			1000	200	39			
Free H2O (mls)			0	100	34			
Temperature (°F)			AMB	6	27			
Angle (°deviation)			90	3	17			
FL Temp °F			*Fluid Loss*	600	50.00			
SFL Temp °F			cc's/30mins:	*Gel Str @*		°F		°F
Ramp hrs:mins				10 sec				
1:		Blow Out Values		10 min				
4:		min:sec	cc's	100lbs/ft²		hrs:mins		hrs:mins
9:				500lbs/ft²		hrs:mins		hrs:mins
16:		*Gas Model*		*Settling@*		°F		Press
25:		Temp °F		Top		Densities lb/gal		Bottom
30:		Pass / Fail						
UCA / Compressive Strength @			80	°F	1000		Pressure (psi)	
50psi:	1:45	hrs:mins	Final Time:		Final Strength:			
500psi:	8:51	hrs:mins	*Comments*					
4 hr:		psi						
12 hr:		psi						
24 hr:	749	psi						
48 hr:	947	psi						
72 hr:	1045	psi						

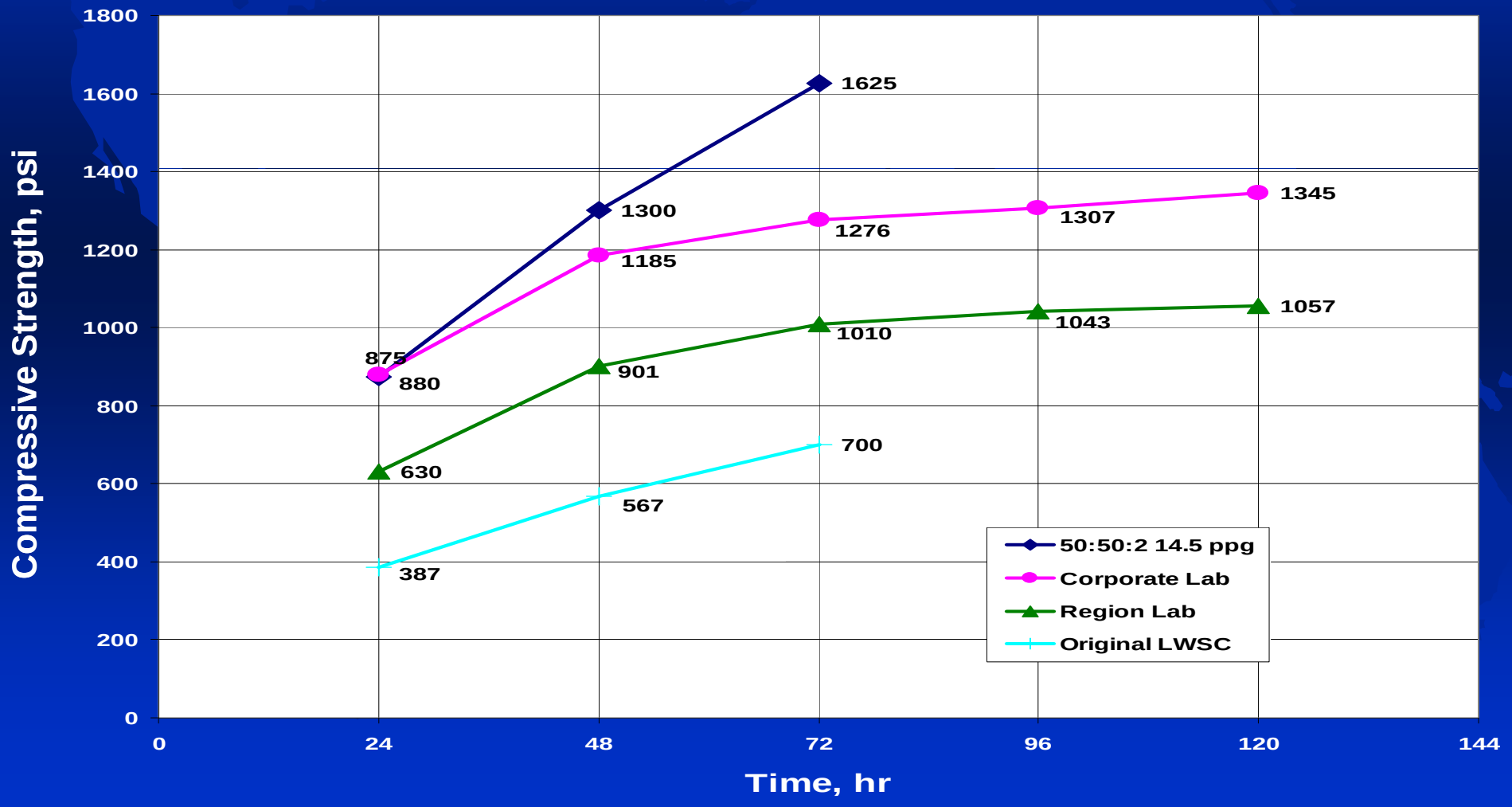
Lab Workup

New Slurry Properties

Thickening Time, Hr:Min	2:41
Temperature, ^{0}F	80
Pressure, psi	1000
Free Water @ 90^0, ml	0
Time to 50 psi, Hr:Min	1:45
Time to 500 psi, Hr:Min	8:51
24 Hr Strength, psi	630
48 Hr Strength, psi	901
72 Hr Strength, psi	1010

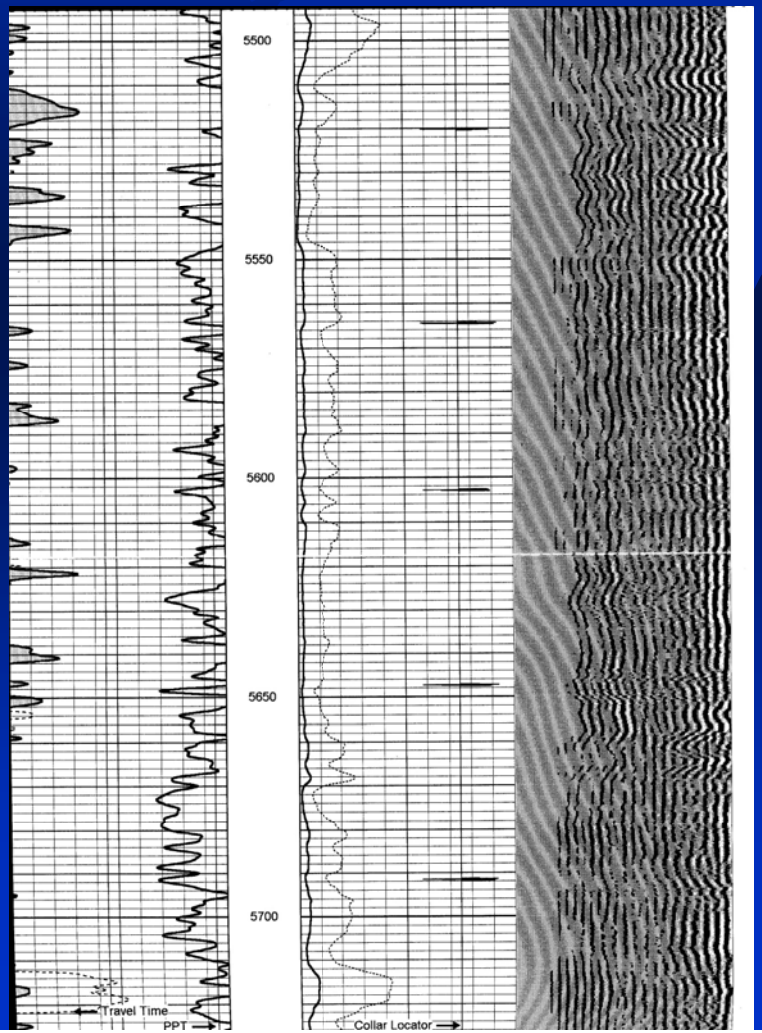
Lab Workup

New Slurry Compressive Strengths



Field Example WV-1
Kanawha County, WV

Good bond log according to CBL/VDL over this interval toward the bottom of the hole. The log was run about 96 hours after the plug was down on the 4-1/2 production casing cement job.



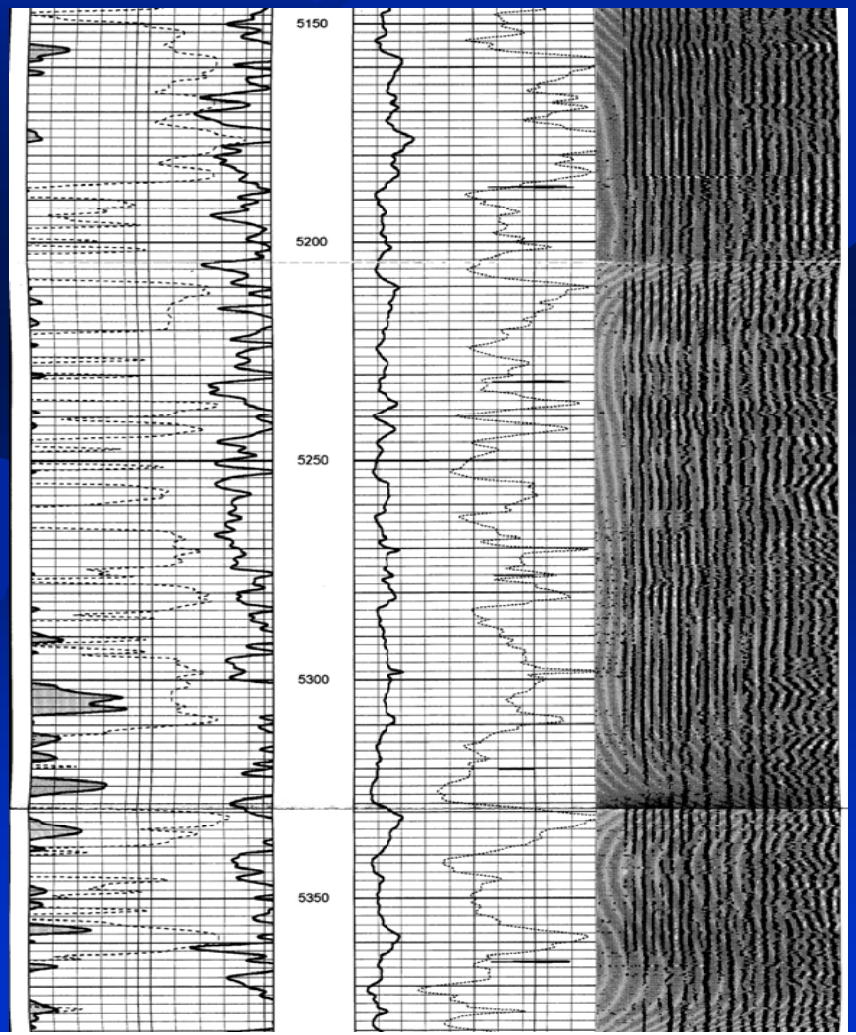
195 sacks

TD = 5,750 ft.

Fill = 3,230 ft.

Field Example WV-2
Kanawha County, WV

Fair to good bond log according to CBL/VDL over this interval toward the bottom of the hole. The log was run about 80 hours after the plug was down.



184 sacks

TD = 5,499 ft.

Fill = 3,549 ft.

Economics Of…

Cycle Time Reduction

- 100 well program, IFP = 200 MSCF
- Gas sells for $5.00/MSCF
- Lost production days = ($1000)/day cash flow
- 5 days per well = 500 days/year
- 500 days x $1000/well = ($500,000)

Economics Of…

Cycle Time Reduction

- New slurry costs $1,500 more
- 100 wells x $1,500 = $150,000
- Reduce WOC time by 5 days per well
- Net value = $500k - $150k = $350k

Conclusions

- Cement does not need several thousand psi compressive strength

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- Cement blend @ 12 ppg achieved 1,000 psi in 72 hours

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- Cement does not need several thousand psi compressive strength
- Cement blend @ 12 ppg achieved 1,000 psi in 72 hours
- New Pozzolan powder and switch to ASTM Type III cement proved to be effective in improving compressive strength of system

Conclusions

- Oilfield casing need not be cemented exclusively with API cements

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- Field application successful

Conclusions

- Oilfield casing need not be cemented exclusively with API cements
- Field application successful
- Cash flow improved for large program

This Point Forward

- API class cement may no longer be available

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- Must develop cement blends using ASTM construction type cement.

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- Look to other industries for potential solutions

This Point Forward

- API class cement may no longer be available
- Must develop cement blends using ASTM construction type cement.
- Look to other industries for potential solutions
- Change our paradigm

Thank You