Welcome!

The program will begin soon.

You will not hear audio until we begin.

INTERSTATE Oil & Gas COMPACT COMMISSION

Production, Classification, and Composition of Cement Used in Oil and Gas Well Construction and Abandonment

Hosted by the Energy, Resources, Research, and Technology Committee

January 12, 2023

1:00 AM-2:30 PM CST

INTERSTATE Oil & Gas COMPACT COMMISSION

IOGCC Cement Webinar

James Heathman, Consultant and current Chair of API Subcommittee 10 on Well Cements

IOGCC Cement Webinar

January 12, 2023

Presented on behalf of the
American Petroleum Institute

by James Heathman

Consultant and current Chair of
API Subcommittee 10 on Well Cements

- Purpose of API Cement classifications and API SPEC 10A
- Differences in the current API cement classifications – not including Classes K & L
- Details of Classes K and L and why created
- Future of API SC10 Activities insofar as limestone use

API SPEC 10A – Some Warranted Clarity

- Provides both chemical and performance specifications
- Created several decades ago to ensure quality control, prior to modern
  - Manufacturing controls and QC methods
  - Understanding of cement reaction chemistry
  - Additive chemistry
- Is a manufacturing specification created for quality control
- Is NOT an end-user specification
- Sometimes misapplied by operators and contractors alike
- API cement Monograms apply only to specific cement mills
- Many mills manufacture cement 'in accordance to' API specifications but because they are not in the API monogram program may not have an audited quality system in place as required by the API monogram program.

API/ISO Chemical Specifications

	Cement class					
	A	B	C	D	G	H
Ordinary grade (O)						
Magnesium oxide (MgO), maximum, percent	6,0	NA[a]	6,0	NA	NA	NA
Sulfur trioxide (SO_3), maximum, percent[b]	3,5	NA	4,5	NA	NA	NA
Loss on ignition, maximum, percent	3,0	NA	3,0	NA	NA	NA
Insoluble residue, maximum, percent	0,75	NA	0,75	NA	NA	NA
Tricalcium aluminate (C_3A), maximum, percent[d]	NR[c]	NA	15	NA	NA	NA

	A	B	C	D	G	H
Moderate sulfate-resistant grade (MSR)						
Magnesium oxide (MgO), maximum, percent	NA	6,0	6,0	6,0	6,0	6,0
Sulfur trioxide (SO_3), maximum, percent[b]	NA	3,0	3,5	3,0	3,0	3,0
Loss on ignition, maximum, percent	NA	3,0	3,0	3,0	3,0	3,0
Insoluble residue, maximum, percent	NA	0,75	0,75	0,75	0,75	0,75
Tricalcium silicate (C_3S) maximum, percent[d]	NA	NR	NR	NR	58	58
minimum, percent[d]	NA	NR	NR	NR	48	48
Tricalcium aluminate (C_3A), maximum percent[d]	NA	8	8	8	8	8
Total alkali content, expressed as sodium oxide (Na_2O) equivalent, maximum, percent[e]	NA	NR	NR	NR	0,75	0,75

	A	B	C	D	G	H
High sulfate-resistant grade (HSR)						
Magnesium oxide (MgO), maximum, percent	NA	6,0	6,0	6,0	6,0	6,0
Sulfur trioxide (SO_3), maximum, percent[b]	NA	3,0	3,5	3,0	3,0	3,0
Loss on ignition, maximum, percent	NA	3,0	3,0	3,0	3,0	3,0
Insoluble residue, maximum, percent	NA	0,75	0,75	0,75	0,75	0,75
Tricalcium silicate (C_3S) maximum, percent[d]	NA	NR	NR	NR	65	65
minimum, percent[d]	NA	NR	NR	NR	48	48
Tricalcium aluminate (C_3A), maximum, percent[d]	NA	3	3	3	3	3
Tetracalcium aluminoferrite (C_4AF) plus twice the tricalcium aluminate (C_3A), maximum, percent[d]	NA	24	24	24	24	24
Total alkali content expressed as sodium oxide (Na_2O) equivalent, maximum, percent[e]	NA	NR	NR	NR	0,75	0,75

*API/ISO Performance Specifications

- Thickening time
- Compressive Strength
- Free Fluid

*Applicable only when prepared using the prescribed percentage of mix water and mixed in accordance to SPEC 10A instructions

Summary of Physical and Performance Requirements from API SPEC 10A

Well Cement Class				A	B	C	D	G	H
Mix water, % mass fraction of cement (Table 5)				46	46	56	38	44	38
Fineness tests (alternative methods) (Clause 6)									
Turbidimeter (specific surface, minimum, m²/kg)				150	160	220	NR[a]	NR	NR
Air permeability (specific surface, minimum, m²/kg)				280	280	400	NR	NR	NR
Free-fluid content, maximum, percent (Clause 8)				NR	NR	NR	NR	5.9	5.9
Compressive strength test (8 hr curing time)	**Schedule number** Table 6	**Final curing temperature** °C (°F)	**Curing pressure** MPa (psi)	**Minimum compressive strength** MPa (psi)					
(Clause 9)	NA[b]	38 (100)	atm	1.7 (250)	1.4 (200)	2.1 (300)	NR	2.1 (300)	2.1 (300)
(Clause 9)	NA	60 (140)	atm	NR	NR	NR	NR	10.3 (1500)	10.3 (1500)
(Clause 9)	6S	110 (230)	20.7 (3000)	NR	NR	NR	3.4 (500)	NR	NR
Compressive strength test (24 hr curing time)	**Schedule number** (Table 6)	**Final curing temperature** °C (°F)	**Curing pressure** MPa (psi)	**Minimum compressive strength** MPa (psi)					
(Clause 9)	NA	38 (100)	atm.	12.4 (1800)	10.3 (1500)	13.8 (2000)	NR	NR	NR
(Clause 9)	4S	77 (170)	20.7 (3000)	NR	NR	NR	6.9 (1000)	NR	NR
(Clause 9)	6S	110 (230)	20.7 (3000)	NR	NR	NR	13.8 (2000)	NR	NR
Thickening-time test	**Specification test schedule number** Tables 9 through 11	**Maximum consistency** (15 min to 30 min stirring period) B_c[c]		**Thickening-time** (minimum/maximum) minutes					
(Clause 10)	4	30		90[d]	90[d]	90[d]	90[d]	NR	NR
(Clause 10)	5	30		NR	NR	NR	NR	90[d]	90[d]
(Clause 10)	5	30		NR	NR	NR	NR	120[e]	120[e]
(Clause 10)	6	30		NR	NR	NR	100[d]	NR	NR

From API SPECIFICATION 10A TWENTY-FIFTH EDITION, MARCH 2019

B.2.1.2 Class K

Class K composite well cement is obtained by intergrinding Portland cement clinker and one or more forms of $CaSO_4$ with silica as specified in B.2.2.1, or by subsequent blending of separately produced Portland cement with separately ground silica flour as specified in B.2.2.1. At the manufacturer's discretion, another constituent (additive) as specified in B.2.2 may be interground or interblended. When added, such other constituents shall be reported to the final user by content and type. This product is intended for use as a basic well cement and is available in O, MSR, and HSR grades, depending on the C3A content of the Portland cement clinker being interground or Portland cement being blended to produce the product.

B.2.1.3 Class L

Class L composite well cement is obtained by intergrinding Portland cement clinker and one or more forms of $CaSO_4$ with fly ash as specified in B.2.2.3; with other pozzolanic material as specified in B.2.2.2; by blending separately produced Portland cement with separately processed fly ash as specified in B.2.2.3; or with other pozzolanic material as specified in B.2.2.2. At the manufacturer's discretion, free-fluid at the manufacturer's design water ratio may be adjusted by using bentonite or other materials that provide suitable particle-suspending properties that, when added to the final product, shall be reported to the final user by content and type. This product is intended for use under conditions when a low- density cement slurry is desired.

Synopsis of Class K and L

- Intergrinding and/or blending Portland cement with silica (K) and pozzolanic materials (L)
- Classes K and L do not directly address intergrinding Portland cement with limestone but does not specifically exclude limestone

The SPEC 10A updates with K & L are a reflection of actual practice

- Use of silica, limestone, and many sources of pozzolanic materials has been practiced for several decades in oil and gas well cementing as both user-blended and manufacturer-created products
- All cement blend end-user needs are driven by technical needs, economics, logistics
- API Classes G and H are the only two remaining API cement classes that do not include interground limestone. This is currently being investigated by API TG02 WG03.

Alternative Materials for Well Cementing

Jason Winegarden, Technical Advisor at NexTier Completion Solutions

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NexTier

Alternative Materials for Well Cementing

Jason Winegarden
January 12, 2023

Topics to Cover

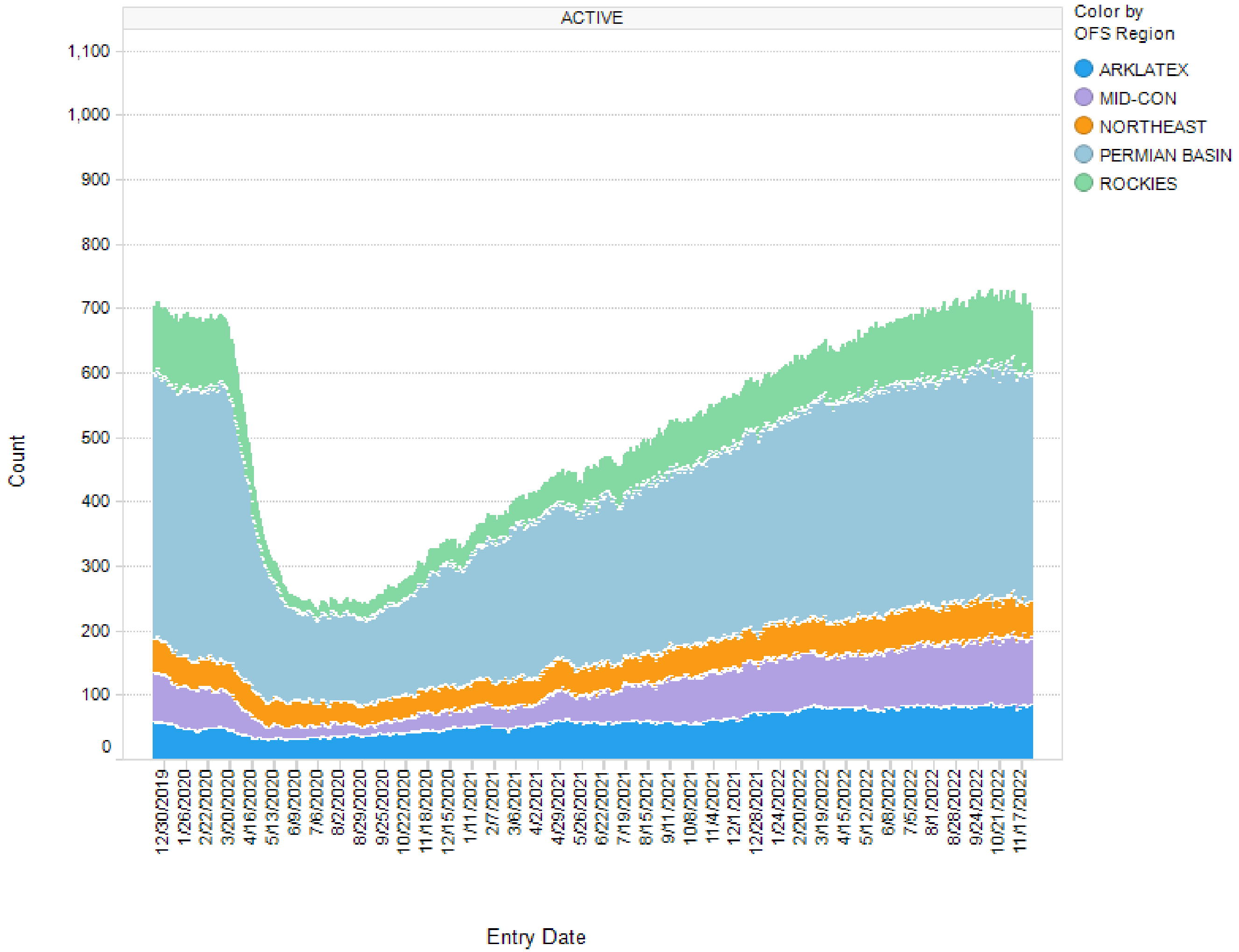
CHANGING MARKET CONDITIONS

SUPPLY CHAIN STRUGGLES

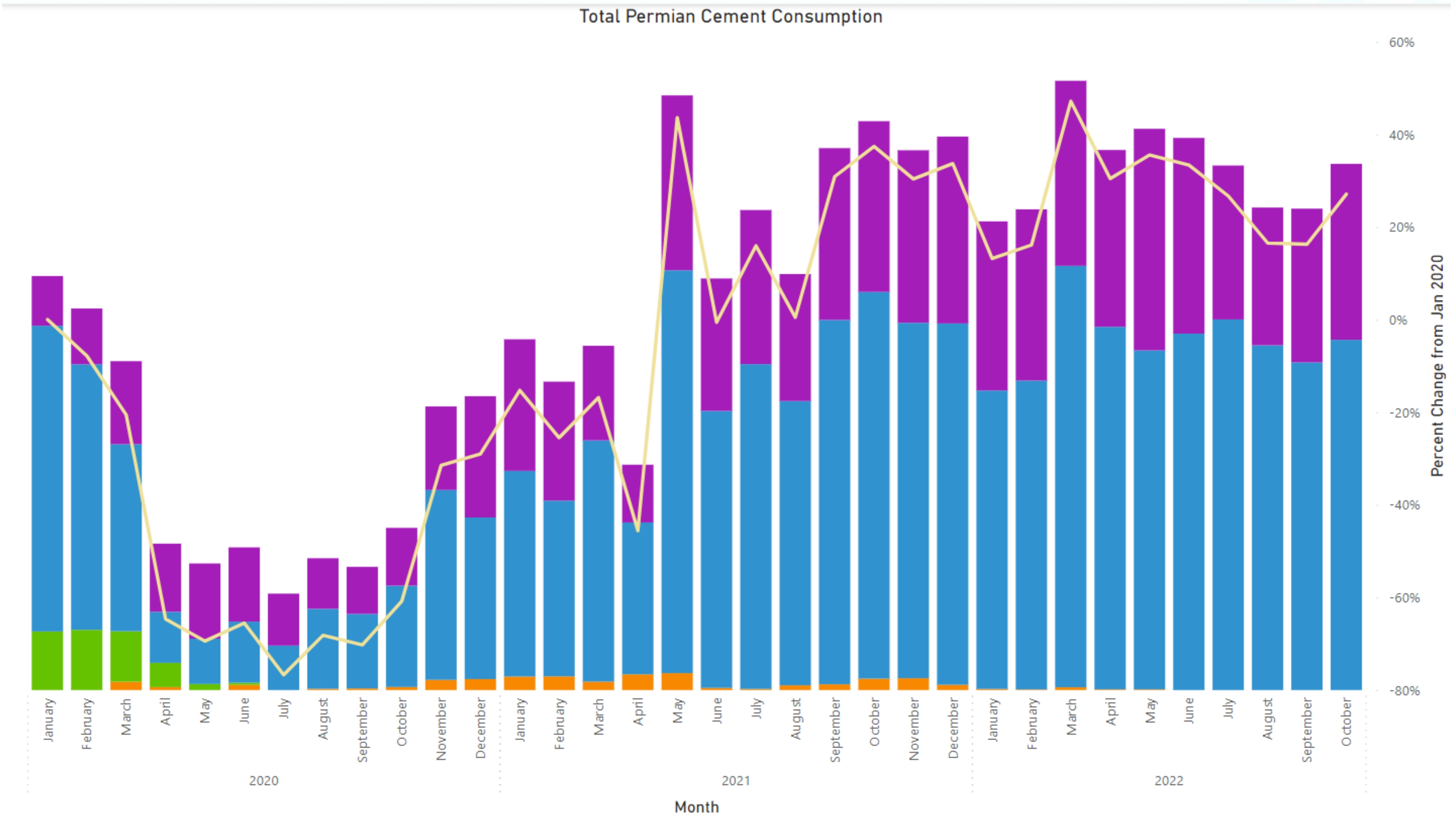
ALTERNATIVE MATERIALS USED

REVIEW OF LAB RESULTS

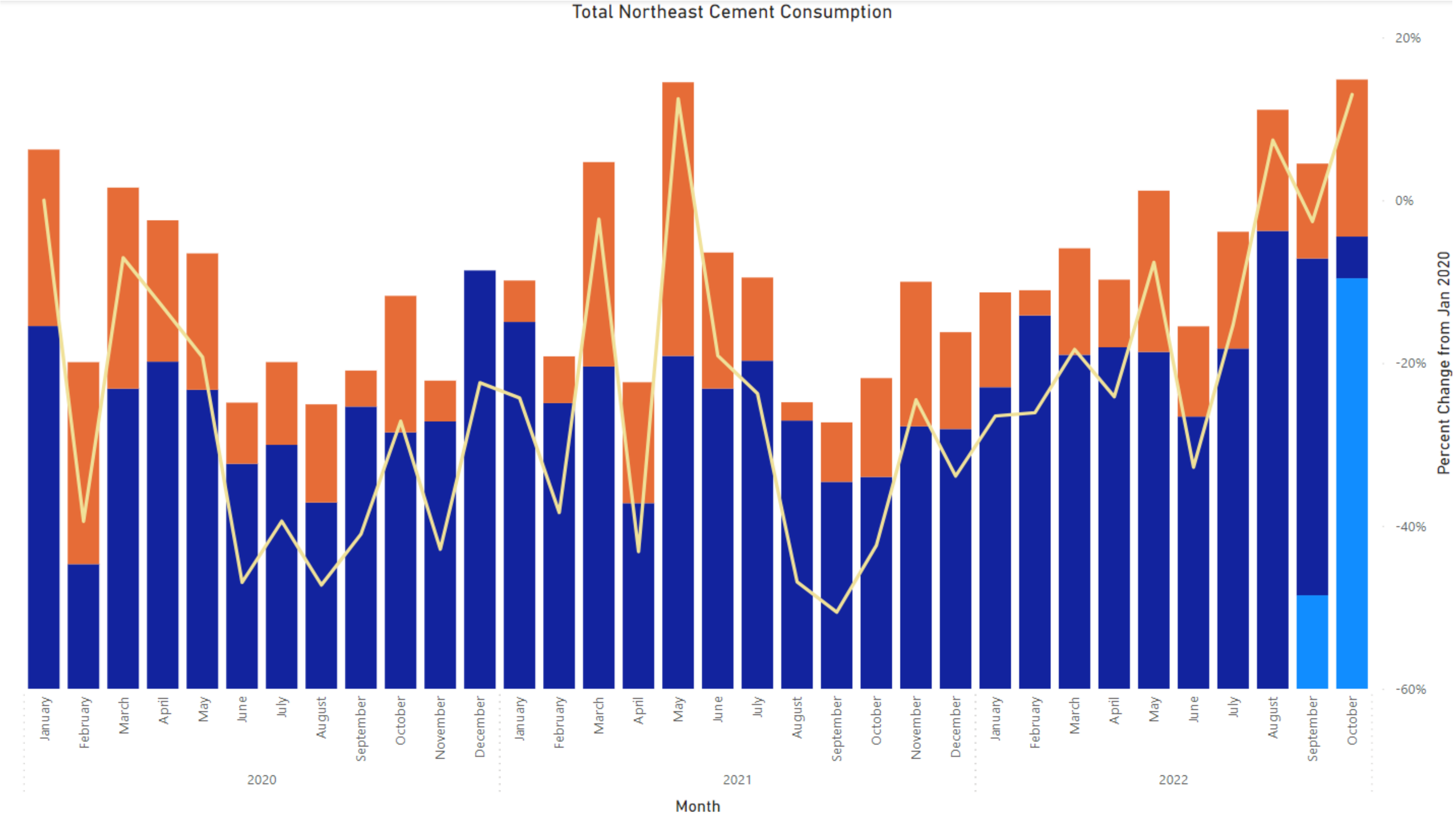
Rig Count – 2020 through Today



Cement Consumption - Permian



Cement Consumption - Appalachia



How Can We Stretch Cement?

Conventional Pozzolans

- Flyash, silica fume
- What is the limit?
  - Reasonable compressive strength results seen up to 60-65% flyash by total weight

Alternative Pozzolans

- Natural Pozzolans – perlite, diatomaceous earth
- Calcined shales – Martin Marietta Lightweight

Inert Fillers

- Nitrogen – foamed cement
- Calcium Carbonate

What Else Can We Use?

Construction Cements	• Type I/II and Type III have a long history of use in oilwell cementing • Construction demand is high, but seasonal
Limestone Blended Construction Cements	• Type IL is replacing Type I/II and Type III in many markets • In use already in well construction in many areas • Options are available to import from other countries also manufacturing blended cements
API Class L Cements	• Limestone Blended Cement (Holcim Class L) • Commercially available lightweight cements (Martin Marietta Lightweight)
Advanced Sealing Materials	• Epoxy Resin • Non-consolidating plugging materials

Lab Results – Blended Cements

Class L vs. Class A (Holcim)

BHCT/BHST (degF)	Base Cement	Density (ppg)	Additives	Time to 70 Bc	Time to 500 psi	CS @ 72 hr (psi)	API Free Fluid (ml/250ml)
108/150	50: 50 Poz:L	12.5	5% NaCl, 6% Bentonite, 1% SMS, 0.15% Retarder	5 hr 42 min	30 hr 02 min	820	2.36
	50:50 Poz:A	12.5	5% NaCl, 6% Bentonite, 1% SMS, 0.15% Retarder	5 hr 53 min	18 hr 53 min	1192	4.44
108/150	50: 50 Poz:L	14.4	5% NaCl, 2% Bentonite, 0.1% Retarder	2 hr 59 min	6 hr 26 min	3172	1.2
	50:50 Poz:A	14.4	5% NaCl, 2% Bentonite, 0.1% Retarder	4 hr 48 min	6 hr 12 min	2443	2.86
160/160	50: 50 Poz:L	14.5	0.2% Viscosifier, 0.2% Fluid Loss, 0.1% Dispersant, 0.2% Retarder	5 hr 27 min	14 hr 50 min	2661	0
	50:50 Poz:A	14.5	0.2% Viscosifier, 0.2% Fluid Loss, 0.1% Dispersant, 0.2% Retarder	8 hr 30 min	10 hr 16 min	2997	0

Type IL vs. Type I vs. Class A (Holcim)

Depth	Base Cement	Density (ppg)	Additives	Time to 70 Bc	Time to 500 psi	Time to 1200 psi	API Free Fluid (ml/250ml)
1000'	Type I	15.6	2% CaCl2	1 hr 55 min	6 hr 59 min	13 hr 44 min	0
	Class A	15.6	2% CaCl2	3hr 44 min	5 hr 53 min	12 hr 50 min	0
	Type IL	15.6	2% CaCl2	1 hr 21 min	3 hr 39 min	6 hr 54 min	0
3000'	Type I	15.6	None	2 hr 23 min	5 hr 12 min	6hr 39 min	0
	Class A	15.6	None	5 hr 20 min	7 hr 13 min	13 hr 20 min	0
	Type IL	15.6	None	2 hr 17 min	4 hr 02 min	5hr 54 min	0
5000'	Type I	14.2	10% NaCl, 2% Bentonite	8 hr 09 min	6 hr 13 min	19 hr 30 min	0
	Type IL	14.2	10% NaCl, 2% Bentonite	5 hr 53 min	5 hr 29 min	16 hr 34 min	0

Class C vs. CPC 40R

Slurry Type	Base Cement	Density (ppg)	Additives	Time to 70 Bc	CS @ 24 hr (psi)	CS @ 72 hr (psi)	API Free Fluid (ml/250ml)
Lead	35:65 Poz:CPC 40	12.8	5% NaCl, 6% Bentonite, 2% Calcium Chloride	6 hr 32 min	391	582	0
	35:65 Poz:C	12.8	5% NaCl, 6% Bentonite, 2% Calcium Chloride	3 hr 46 min	344	563	0
Tail	CPC 40	13.5	5% NaCl, 4% Bentonite, 2% Calcium Chloride, 0.25% SMS	4 hr 09 min	1347	1843	0.2
	Class C	13.5	5% NaCl, 4% Bentonite, 2% Calcium Chloride, 0.25% SMS	2 hr 59 min	702	1185	0
Tail	CPC 40	14.8	2% Calcium Chloride	3 hr 20 min	2204	3149	0
	Class C	14.8	2% Calcium Chloride	2 hr 05 min	1381	2341	0

Summary

- Market conditions changing rapidly
- Service industry is evaluating multiple options for Portland alternatives
- Thorough testing is needed before implementation of alternative technologies
- Comparison testing shows that many options show adequate properties for oilwell use
  - Compressive strength is comparable/adequate
  - Slurry stability is often improved by addition of limestone or other fine pozzolans

Why Low CO_2 Cements

Craig Enos, Technical Services Engineer at LafargeHolcim

INTERSTATE Oil & Gas COMPACT COMMISSION

Why Low CO_2 Cements

Craig Enos - Technical Services Engineer

LafargeHolcim

API vs ASTM Definitions

- **ASTM** - American Society for Testing and Materials (1902)
  - **Type** is the designation for ASTM
  - Standards for Construction Grade Cement
- **API** - American Petroleum Institute (1919)
  - **Class** is he designation for API
  - Standards for Oil & Natural Gas Cement
- Both are Standards organizations operating in parallel
- Both are used for Oil well work

Scope of the cement industry

Cement production reached an estimated 90 million metric tons in the United States in 2020, in comparison to the 4.1 billion metric tons of cement produced worldwide. - EPA

Cement contributes ± 8% of CO2 emissions globally. - IEA

Oil & Gas industry in the US demand point is <1% of total cement production.

1 Metric Ton of Cement Produced = 1 Metric Ton of CO2 released - 2021 PCA Average

Source: 2021 PCA Industry Average

How is the cement and concrete industry viewed?

Guardian concrete week

Concrete: the most destructive material on Earth

After water, concrete is the most widely used substance on the planet. But its benefits mask enormous dangers to the planet, to human health - and to culture itself

VER VIDEO PODCAST NEWSLETTERS BIG THINK

We may have to abandon concrete to fight climate change, architectural experts say

The building material seems so ubiquitous — what can we use in its place?

MATT DAVIS 29 September, 2019

CNN BUSINESS Markets Tech Media Success Perspectives Videos

The cement industry produces more CO2 emissions than most countries. It may not survive

By Charles Riley, CNN Business

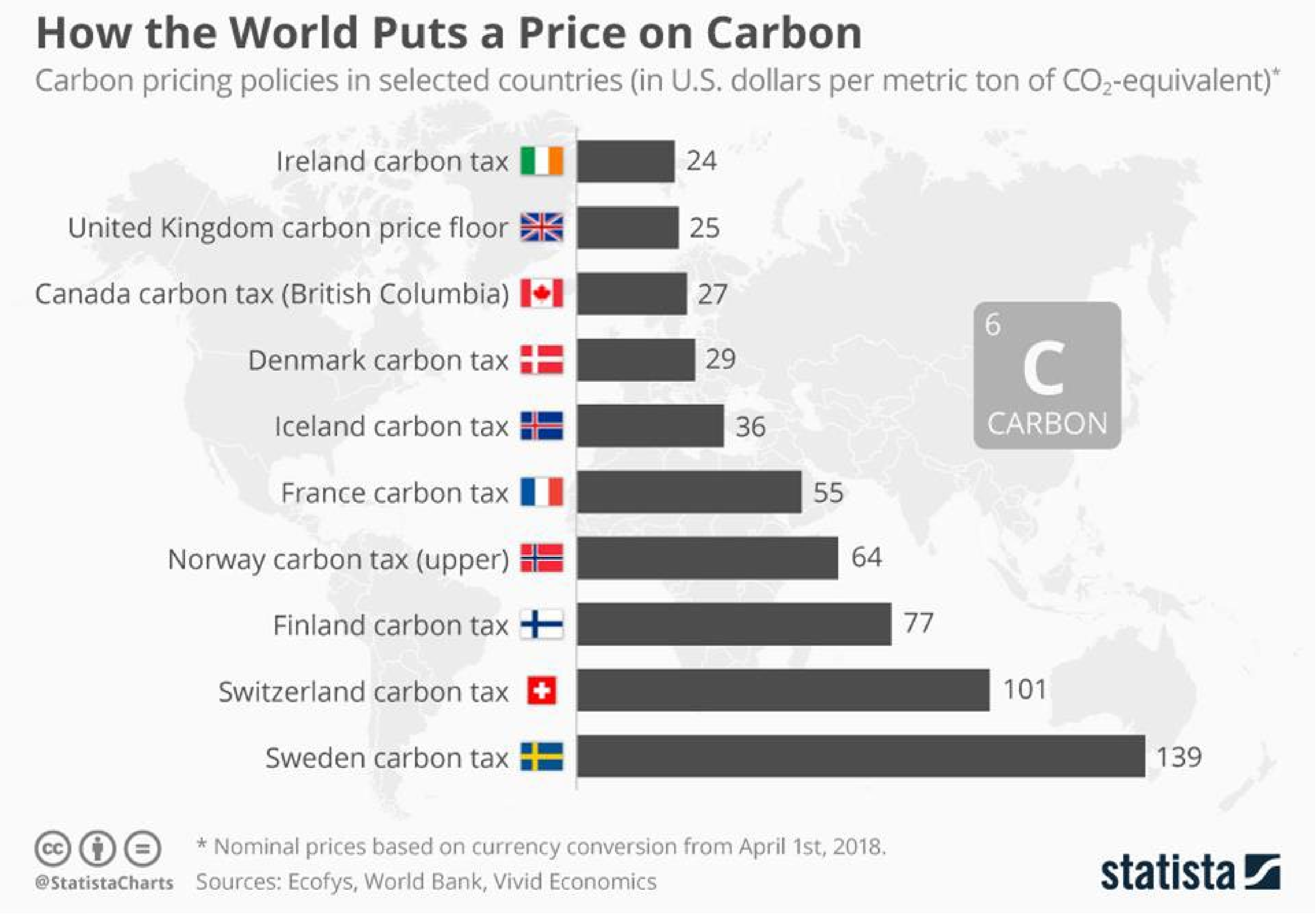
Updated 12:49 PM ET, Mon July 22, 2019

BUSINESS

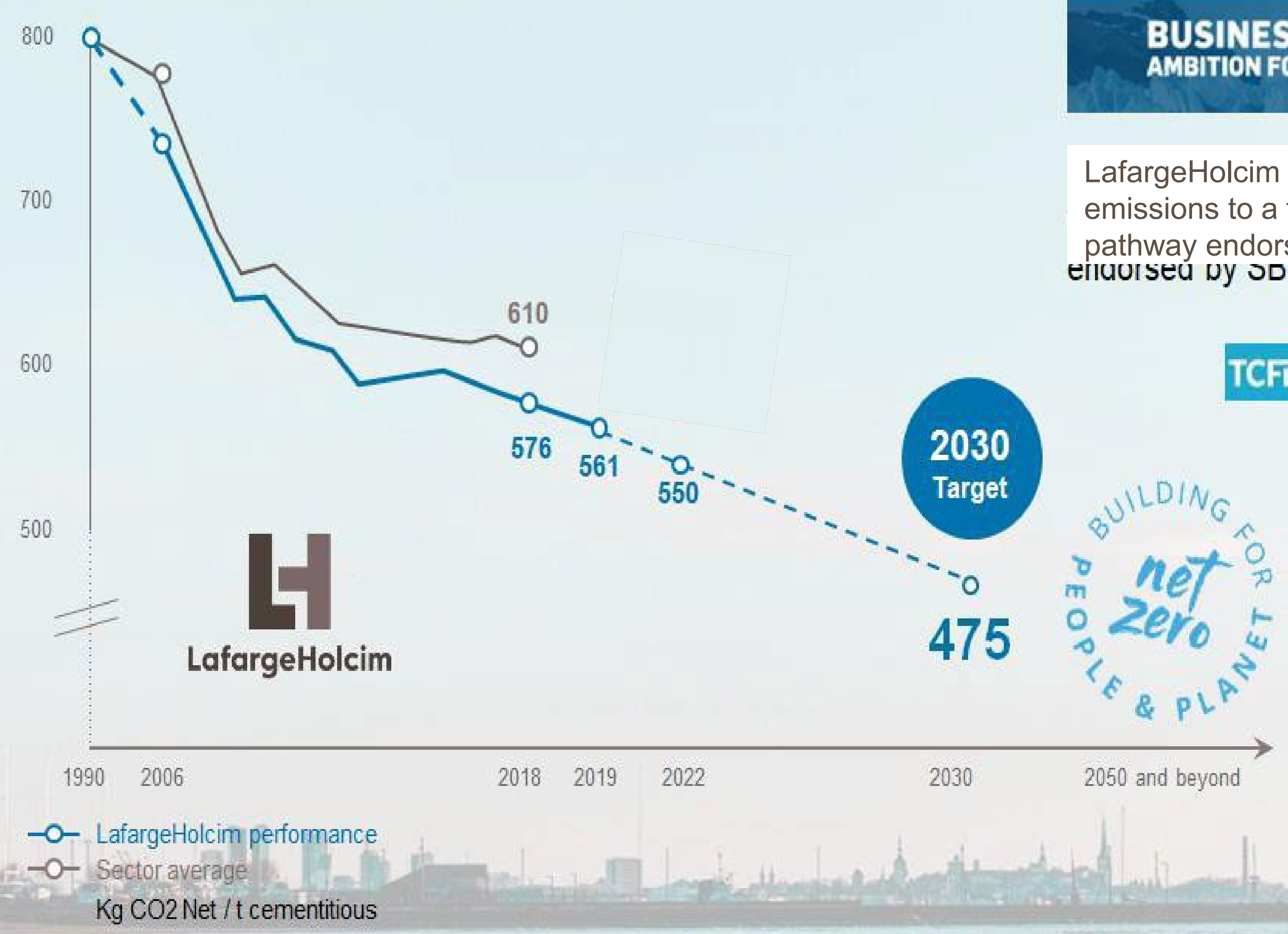
Carbon-intensive cement industry feeling the heat

The cement sector accounts for 7% of all man-made CO2 emissions, more than all 202 million trucks and more than the steel sector. Pressure is piling up on European cement companies to decrease their footprint.

The sustainability movement becomes policy.



Global Industry Initiative & LafargeHolcim Targets

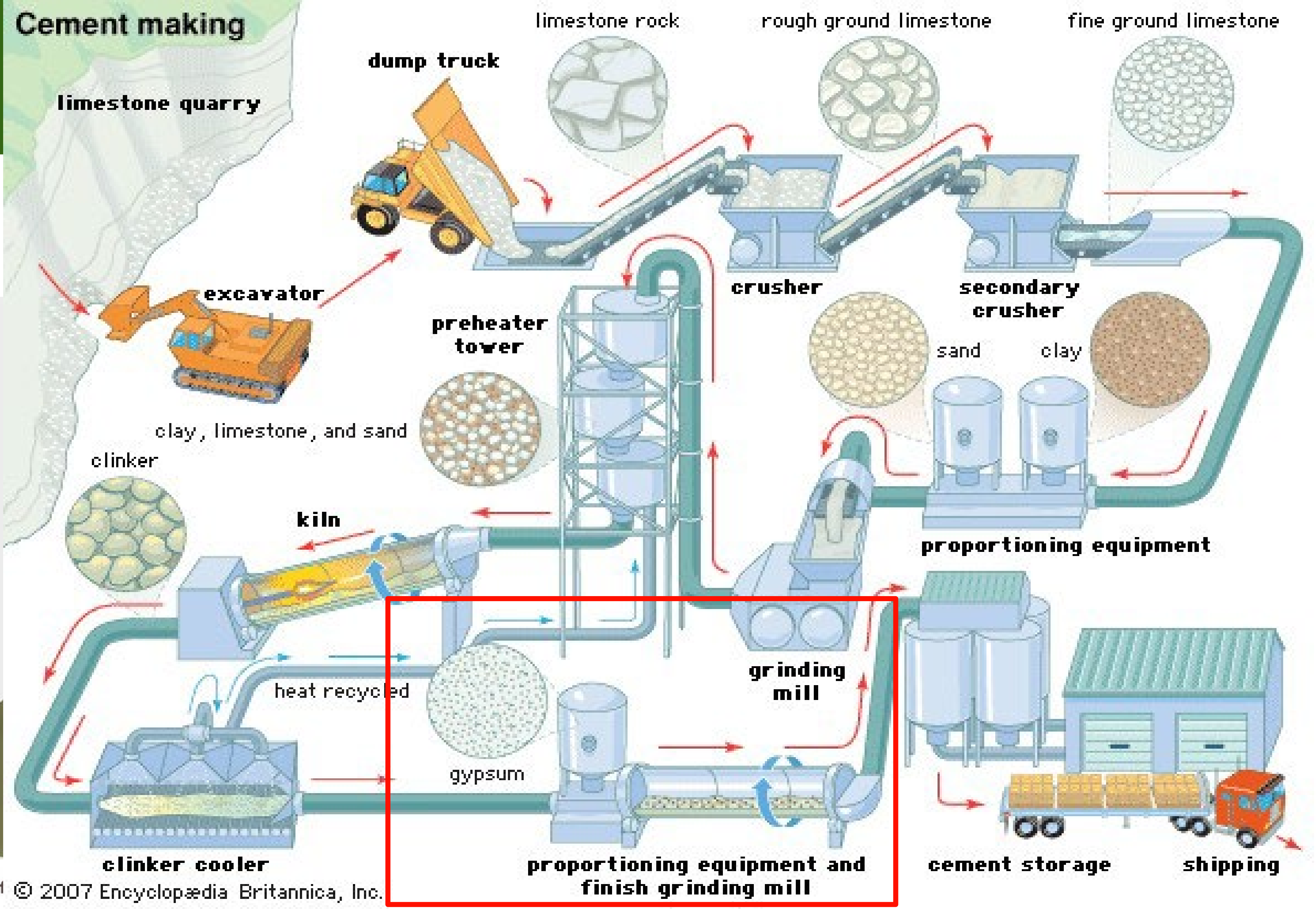


BUSINESS AMBITION FOR 1.5°C

LafargeHolcim will reduce Scope 1 CO_2 emissions to a target consistent with a net-zero pathway endorsed by SBTi

endorsed by SBTi

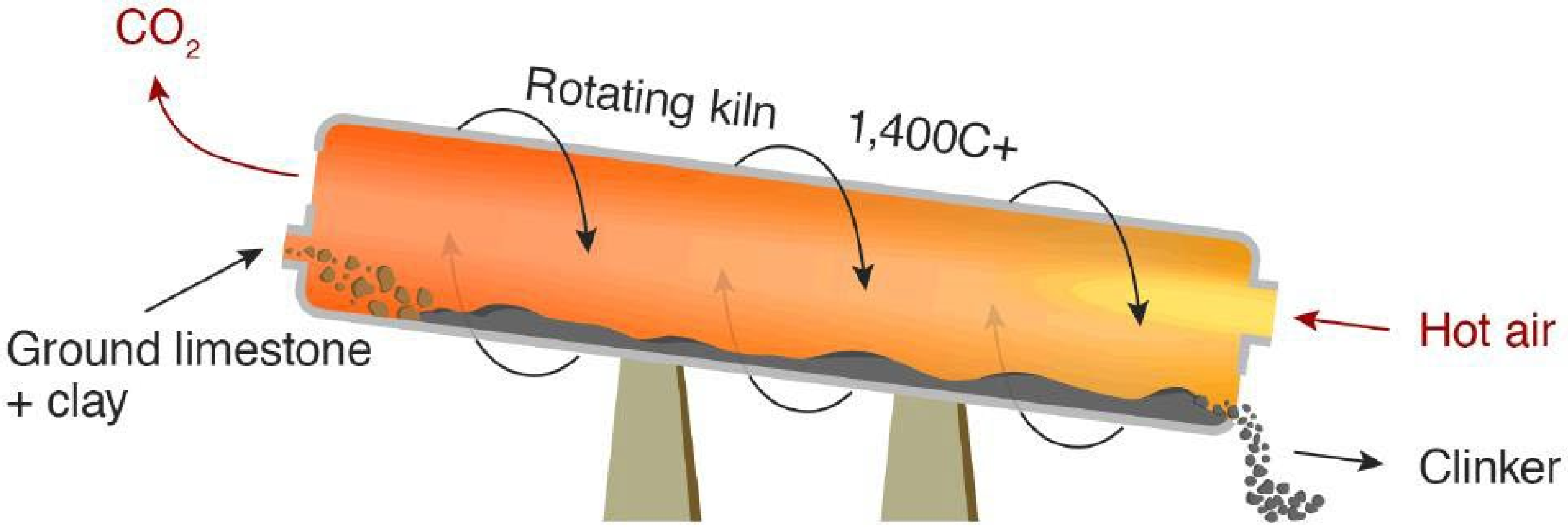
TCFD SCIENCE BASED TARGETS CDP


Cement making
limestone quarry
dump truck
limestone rock
rough ground limestone
fine ground limestone
excavator
crusher
secondary crusher
preheater tower
sand
clay
clay, limestone, and sand
clinker
kiln
proportioning equipment
heat recycled
grinding mill
gypsum
clinker cooler
proportioning equipment and finish grinding mill
cement storage
shipping
© 2007 Encyclopædia Britannica, Inc.

How it is Made - Cement

Rotating cylinder at 2,700°F

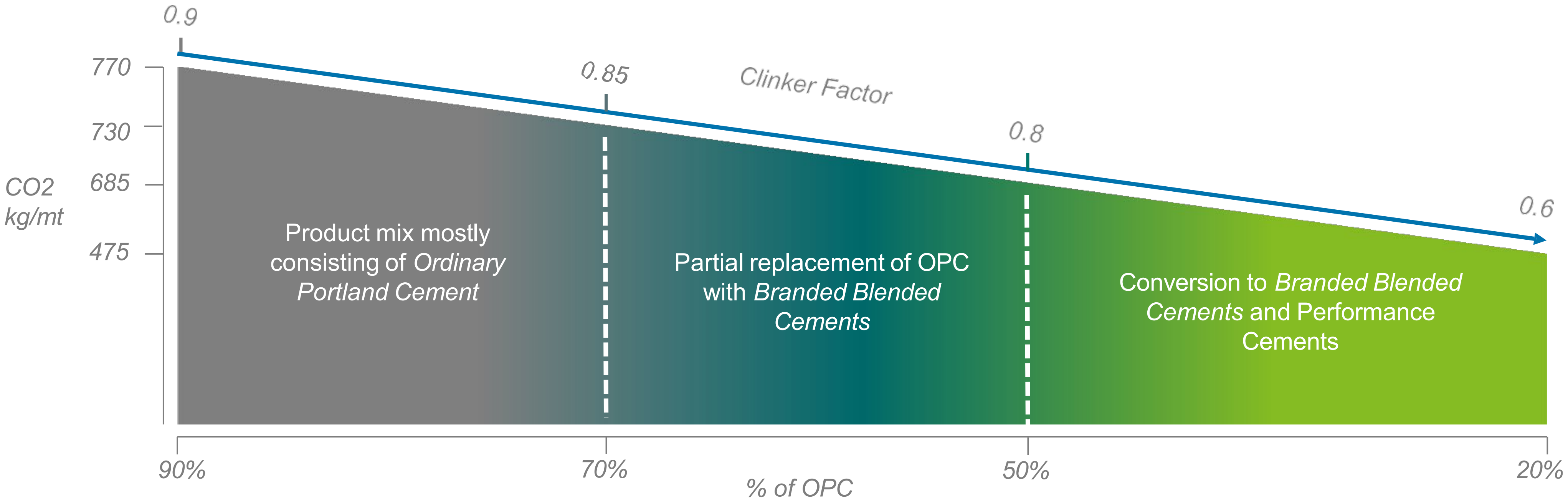
- **Coal, Natural Gas and Alternative fuels**
- **Reduction of Waste to Landfills**
- **Needs significant BTU content**



Source: Carbon Brief, Chatham House

Blended (Interground) Cement

Type IL is the primary cement in most Holcim US Cement Plants



ASTM C150
Ordinary Portland Cement
- *Type I*
- *Type II*
- *Type III*
- *Type V*
- *API (oil well)*

ASTM C595
Blended Hydraulic Cement
- *Type IL (OneCem)*
- *Type IS (MaxCem)*
- *Type IP (FortiCem)*
- *Class L (oil well)*
- *Masonry*

ASTM C1157
Performance Cement
- *EcoPlanet*
- *Solidia*
- *AETHER*
- *AXEL*
- *S-Sorb*
- *Slag (NewCem)*
- *Fly Ash*
- *Natural Pozzolans*
- *Ground glass*

Reviewing Regulatory Requirements

Thomas Hill, Enforcement Administrator at the Ohio Department of Natural Resources

INTERSTATE Oil & Gas COMPACT COMMISSION

Ohio Administrative Code (OAC) Requires:

Well Construction: All cement placed into the well bore shall be manufactured to meet

- API “10A Specifications for Cement and Materials” or ASTM “C150/C150M Cement”
  - WV, PA, Texas have similar requirements
  - Some states are based on performance

Well Plugging:

- If a pozzolan cement mixture is used, pozzolanic material may not exceed 50% by volume
- The OAC did not include ASTM C150 /C150M cement for plugging
- ASTM C595 was not addressed in Well Construction or Plugging

- Most, if not all, current suppliers of API Class A and ASTM C150 Type 1 cement have ceased production of, and are replacing, it with API Class L or ASTM C595 Type 1L cement
- OAC allows the Chief to approve, in writing, cements that may be used to plug or construct a well
- On March 1, 2022 the Chief issued a memorandum approving cement manufactured to meet the standards of ASTM "C150/C150M to be used to plug a well
- September 2, 2022 the Chief issued a memorandum approving cement manufactured to meet ASTM C595 Type 1L to be used in plugging an Orphan Well
- September 2, 2022 the Chief issued a memorandum approving cement manufactured to meet ASTM C595 Type 1L to be used to plug a well
- Applied conditions for the use of Class L cement in well construction and well plugging

- Letters were mailed to all registered owners and registered well pluggers informing them of the changes to the use of cements in well construction and plugging
- Notification must be provided to the applicable Division inspector at least 24 hours prior to use and the inspector must approve of any proposed changes to the cement composition from that required in a permit
- Mill test information must be provided to the applicable Division inspector prior to utilization of Class L and ASTM C595 Type 1L and cement
- Performance data provided in compliance with Ohio rule
- For blended cement, limestone and pozzolanic material shall not exceed 50% by volume
- A person using Class L or Type 1L cement shall leave the plugged well in manner that will allow for further inspection past the three-day requirement

Type 1L and Class L Cement Requirements

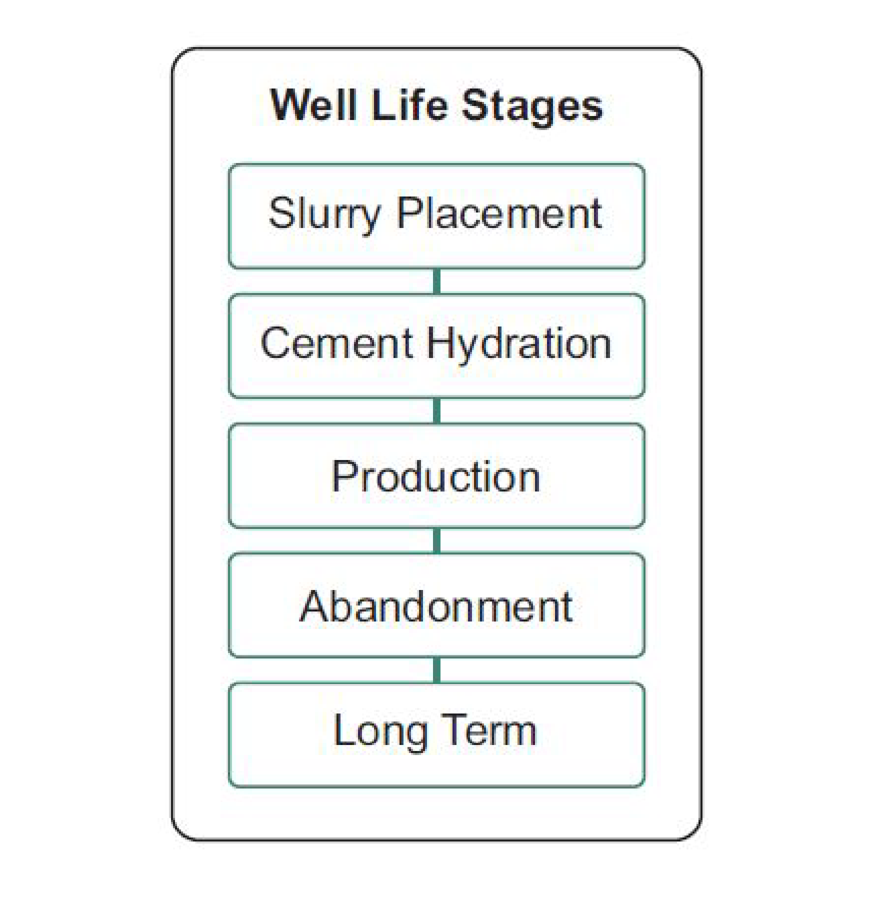
Class L Cement:

- ~21-23% by weight limestone
- ~1% by weight pozzolan

Type 1L Cement

- 5%-15% Limestone

- What is the long-term integrity of the cement sheath when subjected to down hole environments?
- How much performance variability is there depending on the % limestone?
- How resistant is it to changes in pressures and temperatures during the operational lifetime and after?
- Neither cement has published performance date for well bore conditions



Type 1L and Class L Cement Performance

Review Steps Taken

- The Division sent samples of Type 1L to an independent lab for confirmatory testing
- Tracking Type 1L & Class L performance data submitted by industry
- Participating in Cement Research Discussion Group
- Open communication with cement contractors & cement manufactures
- Ohio Technical Advisory Committee completed a study on Type 1L cement and made recommendations

QUESTIONS / DISCUSSION

Interstate Oil & Gas Compact Commission

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THANK YOU FOR ATTENDING!

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