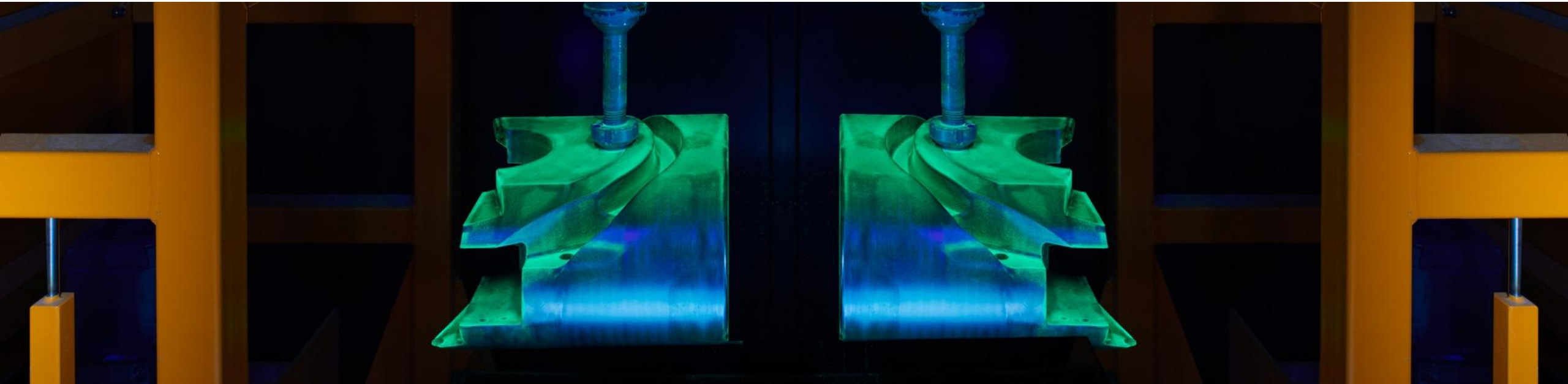
A Sustainable Circular Economy Success Story Using Drilled Cuttings in Cement

Havtil Technical Seminar: ”Plugging and Abandonment of Wells”

7th May 2026



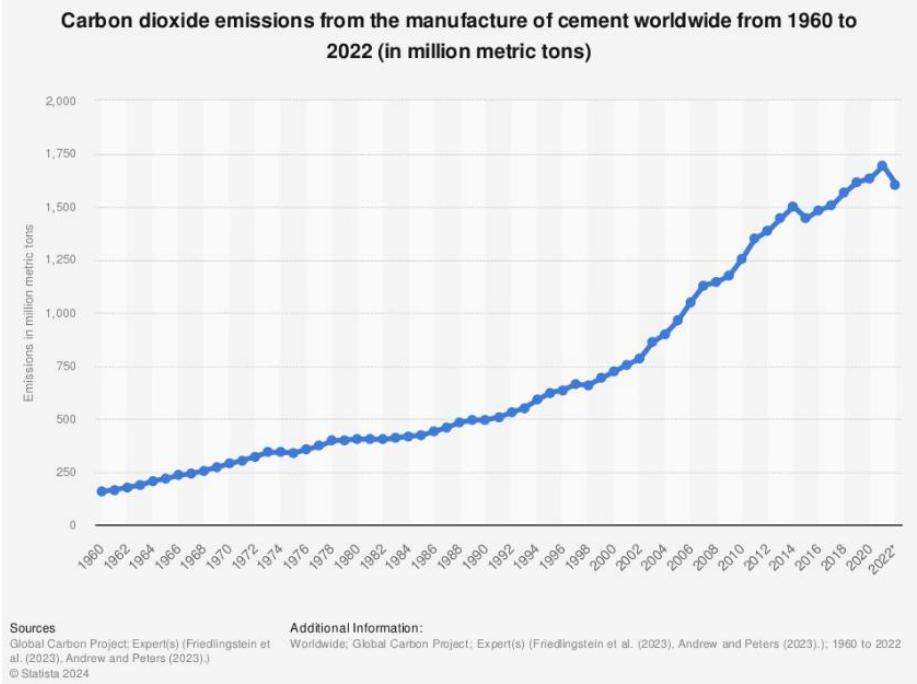
Why is Cement Production so CO_2 Intensive?

- Cement manufacture is responsible for **~8%** of global CO_2 emissions → and rising!

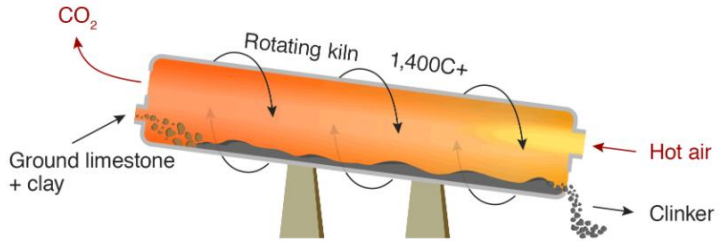
- Around 40% of CO_2 emissions comes from combustion of fuel, fine grinding, etc., and 60% from decarbonization of limestone to form clinker minerals.

- This single chemical reaction is a major emitter of global carbon dioxide emissions:

$$CaCO_3 \rightarrow CaO + CO_2\uparrow$$



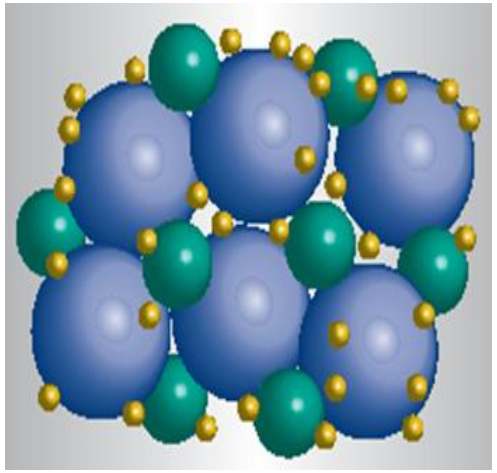
Cement Manufacturing Process



Source: Carbon Brief, Chatham House BBC

Lowering Our Cementing CO_2(e) Footprint: Possible Alternatives?

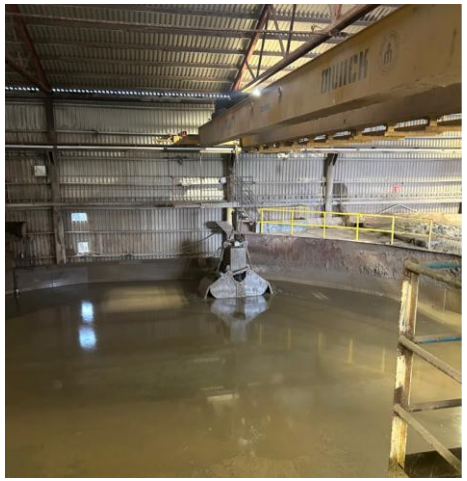
- Lower CO_2 intensive cement blends are used in the oilfield every day.
  - API Class G + silica flour cement → High bottom hole temperature sections
  - Lightweight cement blends → Isolating weak top-hole formations
  - Flexible / expandable cement blends → Dynamic stress environments
- These slurry solutions are not used to lower cementing CO_2(e) footprint due to **COST.**
  - Many blend components are more expensive than cement
  - Blending requires additional labour and logistics
  - Significant R&D investment to develop blended solutions
- Need to ensure blend components are significantly cheaper than Portland cement to recovered the above costs.



Base Oil Recovery: The Start of Our Journey

- In Norway, 10’s k MT of oil-wet drilled cuttings / slops are generated and backloaded for disposal via land fill each year.
- A “Thermomechanical Cuttings Cleaner” (TCC) process is utilized to process the cuttings and separate them from base oil.
- By the end of the TCC process, a significant quantity of processed cuttings are generated, which until recently had no identified technical function.

Extraction from ‘‘Cuttings Pit’’

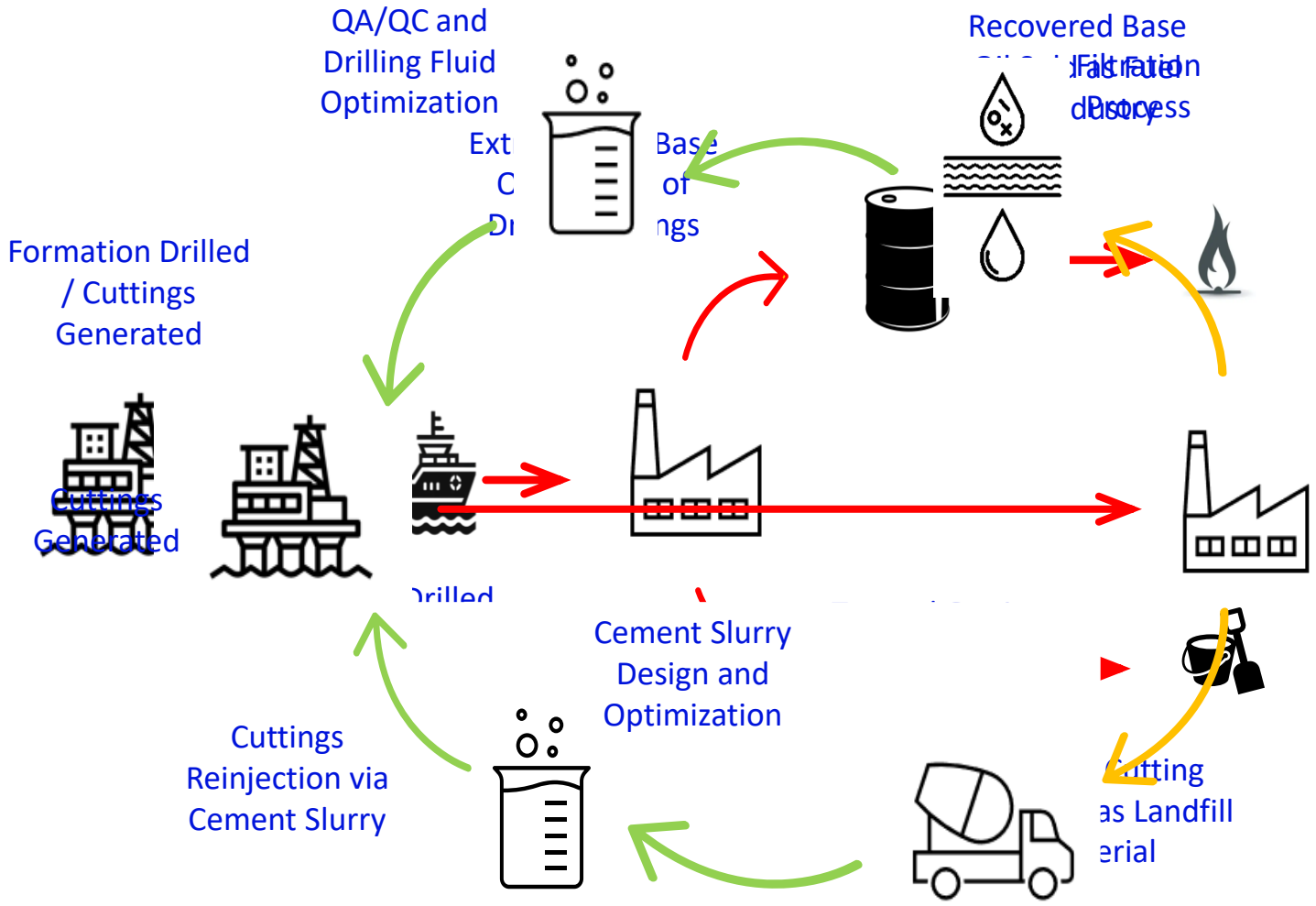


Heating Process to Separate Base Oil / Drilled Cuttings

Processed Dried Cuttings Transported to Skips

“Closing the Loop”: A Sustainable Transition to a Circular Economy

- Study initiated to determine feasibility of incorporating processed drilled cuttings into conventional cement blends.
- Could we generate fit-for-purpose cement slurries for field use?
- This “circular economy” approach had the potential to:
  a) Reduce the CO_2(e) footprint of delivered cement blends / slurries.
  b) Reduce demand for new products when planning subsequent operations.



Qualification Process

- Would a Drilled Cuttings Cement Blend (DCCB) be:

a) Technically Feasible?

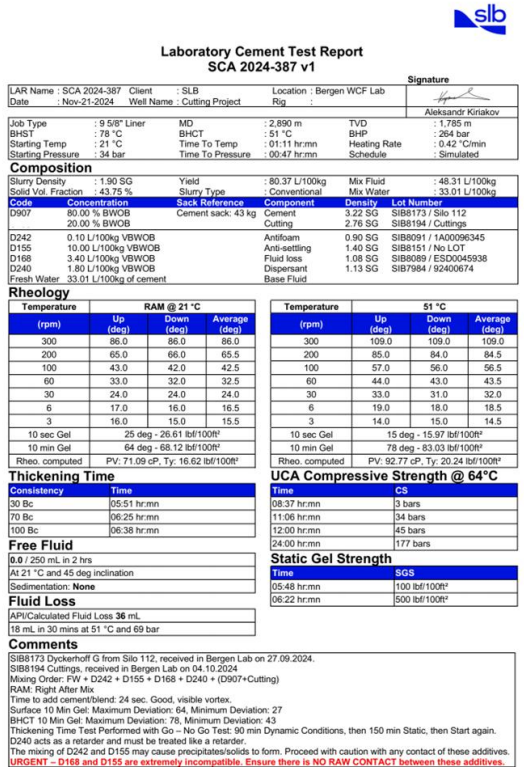
- Performance Testing (API RP 10B-2, 2024)
- Blend Characterization
- Blend Flowability

b) Operationally Safe?

- Chemical Composition
- Respirable Particle Content
- SDS Creation

c) A Robust Well Barrier Material?

- Compressive Strength Development / Trend
- Set Cement Permeability



Laboratory Cement Test Report
SCA 2024-387 v1

LAR Name	: SCA 2024-387	Client	: SLB	Location	: Bergen WCF Lab
Date	: Nov-21-2024	Well Name	: Cutting Project	Rig	:

Signature: Aleksandr Kiriakov

Job Type	: 9 5/8" Liner	MD	: 2,890 m	TVD	: 1,785 m
BHST	: 78 °C	BHCT	: 51 °C	BHP	: 264 bar
Starting Temp	: 21 °C	Time To Temp	: 01:11 hr:mn	Heating Rate	: 0.42 °C/min
Starting Pressure	: 34 bar	Time To Pressure	: 00:47 hr:mn	Schedule	: Simulated

Composition

Slurry Density	: 1.90 SG	Yield	: 80.37 L/100kg	Mix Fluid	: 48.31 L/100kg
Solid Vol. Fraction	: 43.75 %	Slurry Type	: Conventional	Mix Water	: 33.01 L/100kg

Code	Concentration	Sack Reference	Component	Density	Lot Number
D907	80.00 % BWOB 20.00 % BWOB	Cement sack: 43 kg	Cement Cutting	3.22 SG 2.76 SG	SIB8173 / Silo 112 SIB8194 / Cuttings
D242	0.10 L/100kg VBWOB		Antifoam	0.90 SG	SIB8091 / 1A00096345
D155	10.00 L/100kg VBWOB		Anti-settling	1.40 SG	SIB8151 / No LOT
D168	3.40 L/100kg VBWOB		Fluid loss	1.08 SG	SIB8089 / ESD0045938
D240	1.80 L/100kg VBWOB		Dispersant	1.13 SG	SIB7984 / 92400674
Fresh Water	33.01 L/100kg of cement		Base Fluid		

Rheology

Temperature	RAM @ 21 °C		
(rpm)	Up (deg)	Down (deg)	Average (deg)
300	86.0	86.0	86.0
200	65.0	66.0	65.5
100	43.0	42.0	42.5
60	33.0	32.0	32.5
30	24.0	24.0	24.0
6	17.0	16.0	16.5
3	16.0	15.0	15.5
10 sec Gel	25 deg - 26.61 lbf/100ft²		
10 min Gel	64 deg - 68.12 lbf/100ft²		
Rheo. computed	PV: 71.09 cP, Ty: 16.62 lbf/100ft²		

Temperature	51 °C		
(rpm)	Up (deg)	Down (deg)	Average (deg)
300	109.0	109.0	109.0
200	85.0	84.0	84.5
100	57.0	56.0	56.5
60	44.0	43.0	43.5
30	33.0	31.0	32.0
6	19.0	18.0	18.5
3	14.0	15.0	14.5
10 sec Gel	15 deg - 15.97 lbf/100ft²		
10 min Gel	78 deg - 83.03 lbf/100ft²		
Rheo. computed	PV: 92.77 cP, Ty: 20.24 lbf/100ft²		

Thickening Time

Consistency	Time
30 Bc	05:51 hr:mn
70 Bc	06:25 hr:mn
100 Bc	06:38 hr:mn

UCA Compressive Strength @ 64°C

Time	CS
08:37 hr:mn	3 bars
11:06 hr:mn	34 bars
12:00 hr:mn	45 bars
24:00 hr:mn	177 bars

Free Fluid

0.0 / 250 mL in 2 hrs
At 21 °C and 45 deg inclination
Sedimentation: **None**

Static Gel Strength

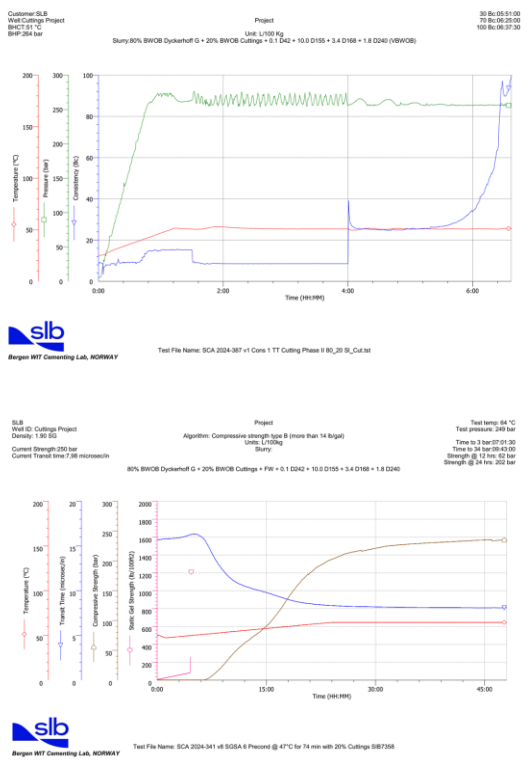
Time	SGS
05:48 hr:mn	100 lbf/100ft²
06:22 hr:mn	500 lbf/100ft²

Fluid Loss

API/Calculated Fluid Loss **36** mL
18 mL in 30 mins at 51 °C and 69 bar

Comments

SIB8173 Dyckerhoff G from Silo 112, received in Bergen Lab on 27.09.2024.
SIB8194 Cuttings, received in Bergen Lab on 04.10.2024
Mixing Order: FW + D242 + D155 + D168 + D240 + (D907+Cutting)
RAM: Right After Mix
Time to add cement/blend: 24 sec. Good, visible vortex.
Surface 10 Min Gel: Maximum Deviation: 64, Minimum Deviation: 27
BHCT 10 Min Gel: Maximum Deviation: 78, Minimum Deviation: 43
Thickening Time Test Performed with Go – No Go Test: 90 min Dynamic Conditions, then 150 min Static, then Start again.
D240 acts as a retarder and must be treated like a retarder.
The mixing of D242 and D155 may cause precipitates/solids to form. Proceed with caution with any contact of these additives.
URGENT – D168 and D155 are extremely incompatible. Ensure there is NO RAW CONTACT between these additives.



Criteria	Acceptable Limits for Onshore	Acceptable Limits for Offshore	Blend Results	Acceptability
Flowability	CI < 31% or HR < 1.45	CI < 31% or HR < 1.46	22% 1.27	Passable Acceptable for on and offshore
	FFc > 2	FFc > 2.5	2.74	Weakly Cohesive Acceptable for on and offshore
	AE (3mm/s) <400mJ	AE (3mm/s) <300mJ	279	Weakly Cohesive Acceptable for on and offshore
Non-Segregation Robustness	Cv < 6%	Cv < 4%	0.5	Very Robust Acceptable for on and offshore

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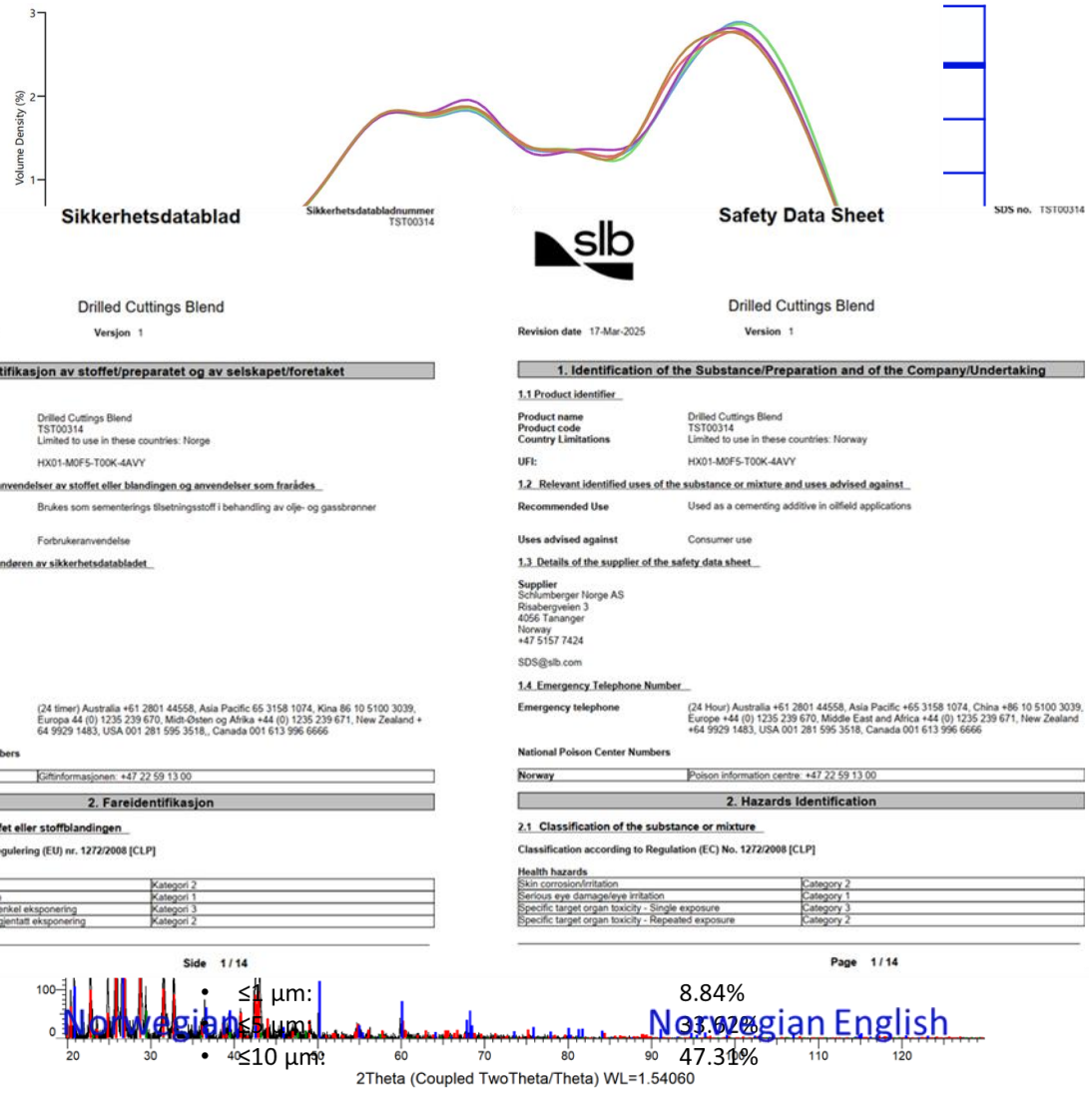

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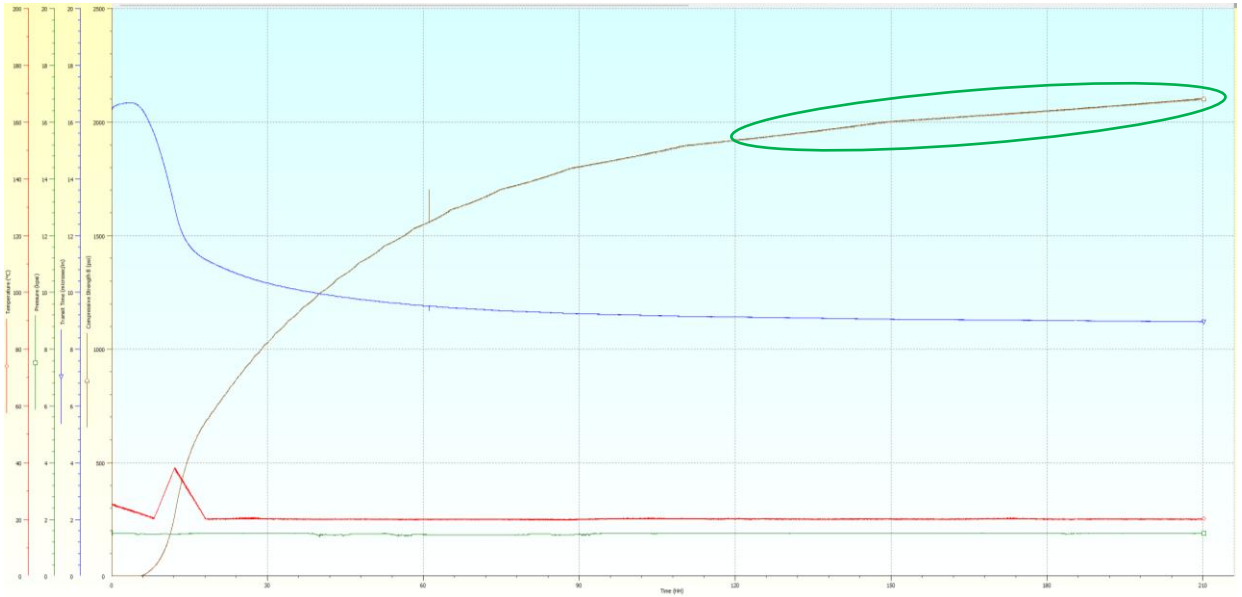


- ✓ No Compressive Strength Deterioration
- ✓ Water Permeability Testing Result – **<u>7 nD</u>**

Field Candidate Selection

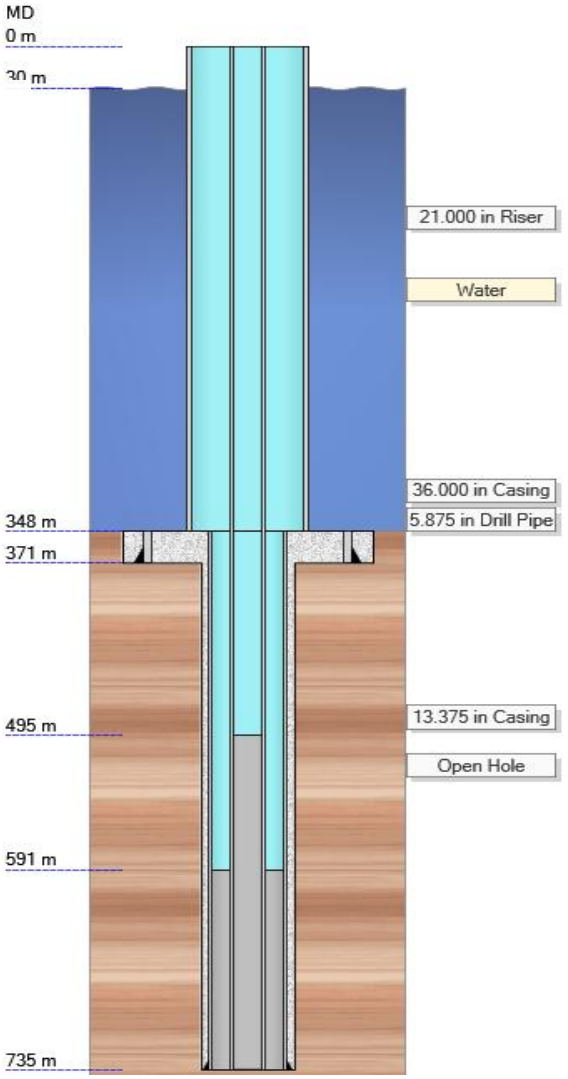
- ✓ Low risk operation
- ✓ Verification not required as per NORSOK D-010

Job Objective	
Primary	Place 150 m cement plug inside the 13 ⅜” casing on top of a mechanically set plug to permanently abandon the well.

Acceptance Criteria	
Primary	Plug #4 execution as per plan (RIH to tag top of cement would proceed if rig operations allowed)

Pumping Schedule

Fluid Name	Stage Volume (m^3)	Pump Rate (lpm)	Stage Time (hr:mn)	Cum. Time (hr:mn)	Comment
Sponge Ball			00:10	00:10	Drop sponge ball ahead of slurry
Cement Slurry (1.92 SG)	11.8	500	00:24	00:34	Mix and pump slurry
Sponge Ball			00:10	00:44	Drop sponge ball behind slurry
Sea Water:	6.2		00:08		
> Sea Water	4.2	1000	00:04	00:48	Continue displacement
> Sea Water	2.0	600	00:03	00:51	Slowdown displacement rate



Job Execution

- Bulk transfers proceeded seamlessly with no stoppages observed.
- Perfectly mixable slurry and easy to weigh up to desired density.
- No abnormal pump pressures were experienced during job execution.
- Displacement and POOH proceeded according to plan.
- TOC verification was cancelled, however cup samples and “Bucket Test” sample set earlier vs. onshore UCA chart.
- Outstanding operator feedback.

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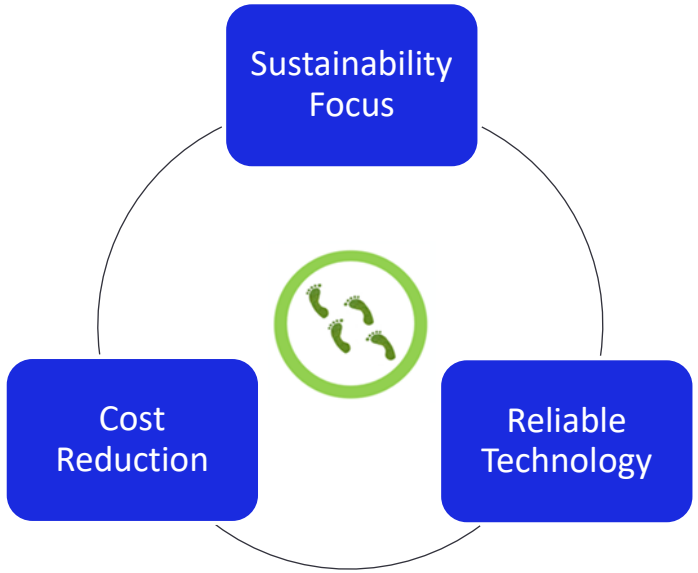
Conclusions and Forward Plan



- Concept of incorporating drilled cuttings as a filler in cement was proven:
  - ✓ Technically Feasible
  - ✓ Operationally Safe
  - ✓ Robust Well Barrier Material
- Trial operation was flawlessly executed in the field, thus validating all qualification testing.
- Represents a novel and exciting concept with immense upscaling potential on the Norwegian Continental Shelf and beyond.
- A sustainable circular economy success story allowing:
  - ✓ Provide a purposeful use for materials previously considered as waste.
  - ✓ Reduce the CO_2(e) footprint of delivered cement blends / slurries.
  - ✓ Reduce demand for new products when planning cementing operations.

Questions / Thoughts?