

Fangmann Energy Services

Competence | Flexibility | Reliability

Specially Customized System for Cementing Geothermal Wells

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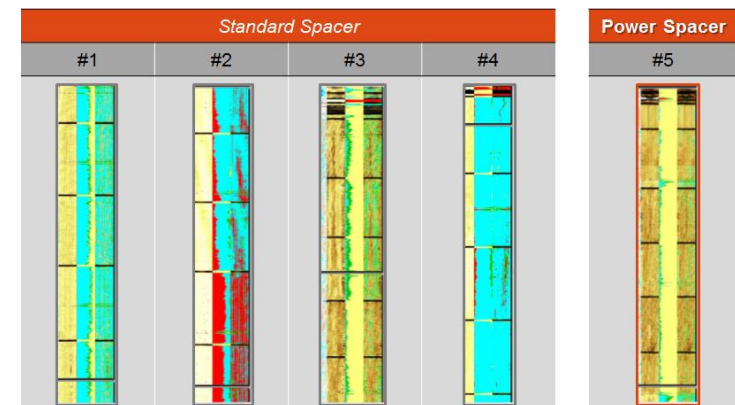
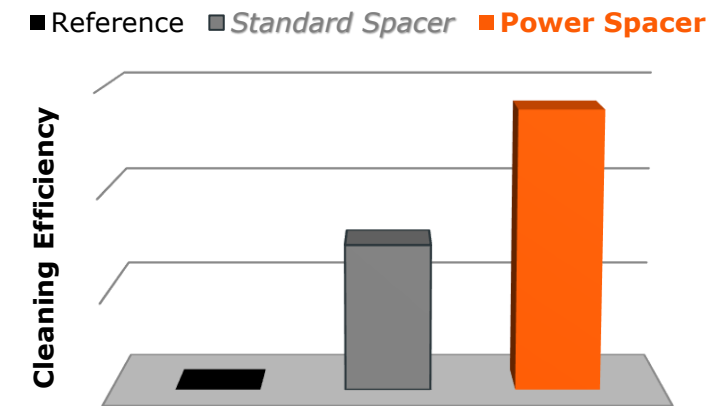
Der Geothermiekongress
Essen, October 17, 2023



Efficient Well Cleaning: Power Spacer

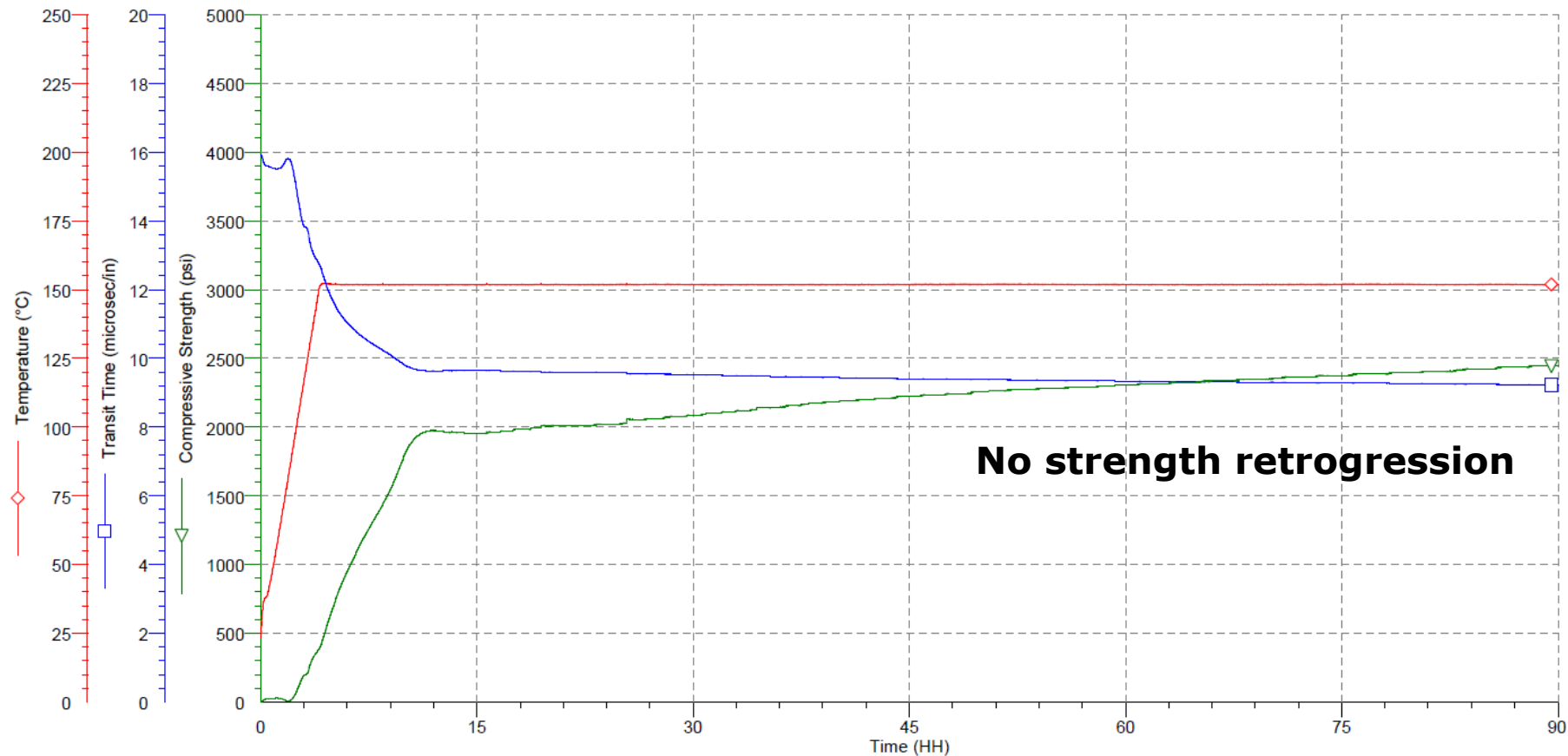
Well preparation is the key

- ✓ Enhanced mud removal compared to standard systems
- ✓ Excellent cement bonding as proven via logging
- ✓ Impressive increase in removed mud residue (visible on shale shaker screens)
- ✓ No detrimental erosion of downhole / surface equipment
- ✓ Recommended pre-treatment prior to cementing



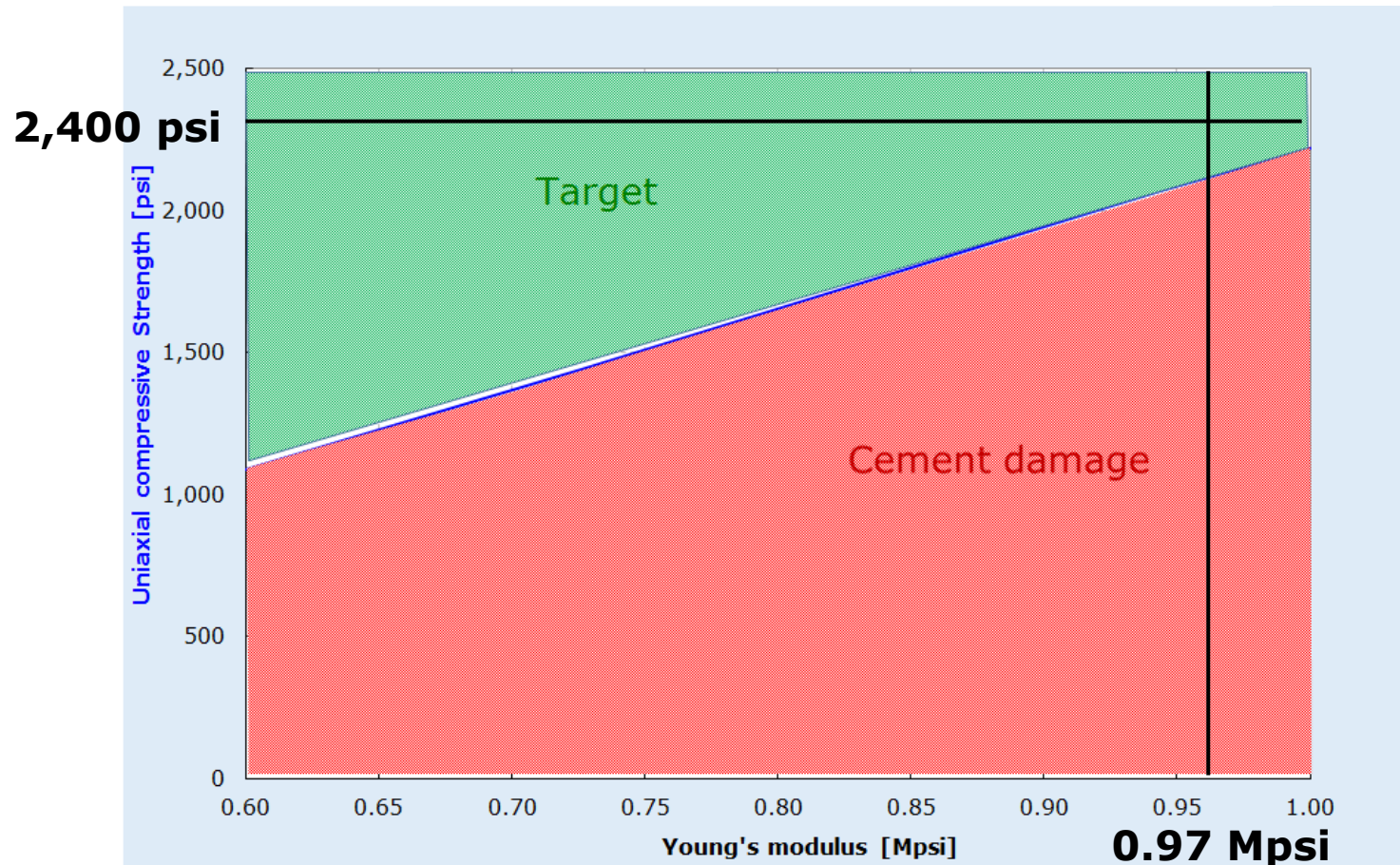
High-Temperature Stability: Thermalite

Silica content > 35% + light-weight additives



High-Temperature Stability: Thermalite

Blend and fluid optimization based upon lab testing and simulations



High-Temperature Stability: Thermalite

Lab results

1.4 kg/ltr <i>pro 1m³ Spacer</i>		Power Spacer	Spacer	◀	▶		LOT	R1B5	Rheology	
		<i>Code</i>	<i>Name</i>	<i>pro 1.0 m³</i>					T1 22 °C	
715.2	ltr	FRWA	Fresh water	715.2	ltr	Bohrung		3 rpm	12.0	
1.0	ltr	CAF_902	Antifoam	1.0	ltr			6 rpm	14.0	
50.0	kg	CSP_205	Special	50.0	kg			30 rpm	18.5	
150.0	kg	CXT_650	Extender	150.0	kg			60 rpm	22.0	
485.9	kg	CWA_831	Weighing Agent	485.9	kg			100 rpm	25.0	
								200 rpm	30.5	
								300 rpm	35.0	
								600 rpm	46.0	
1000.0	ltr	Yield								

High-Temperature Stability: Thermalite

Lab results

1.6 kg/ltr		Zement 1	MF 58.7%	◀	▶		LOT	R1B1	Rheology	
<i>per mt Cement</i>		<i>Code</i>	<i>Name</i>	<i>pro 1.0 m³</i>					T1 22 °C	
625.1	lt	FRWA	Fresh water	584.1	lt	Bohrung		3 rpm	10.5	
1.0	lt	CAF_902	Antifoam	0.9	lt			6 rpm	13.5	
5.0	kg	CXT_621	Extender	4.7	kg			30 rpm	21.0	
								60 rpm	24.0	
								100 rpm	28.0	
								200 rpm	35.0	
								300 rpm	45.0	
								600 rpm	72.0	
								TT		100Bc 426 min
								FL		
1083.1	kg	Thermalite 1,6	Cement	1.0	ton	Bohrung		FF		
1070.2	ltr	Yield						CS		

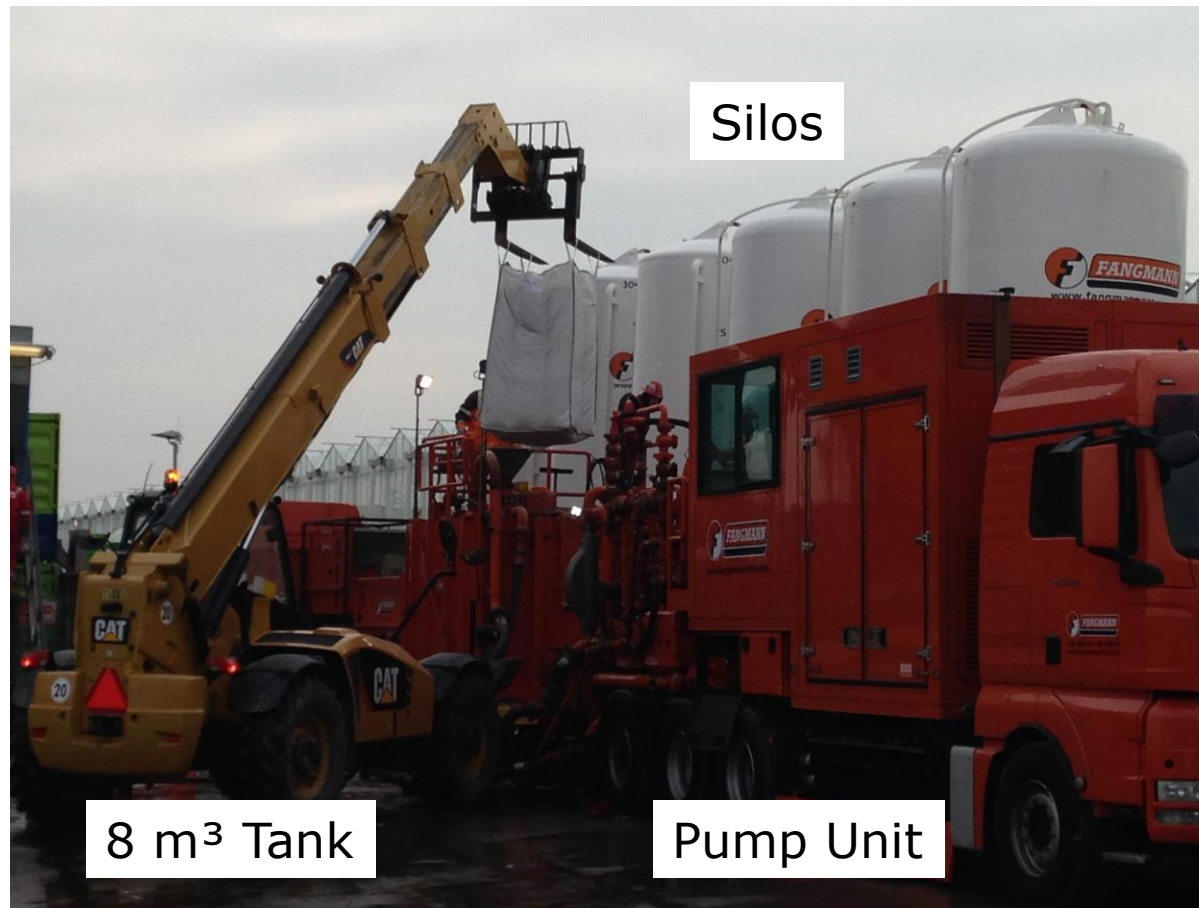
High-Temperature Stability: Thermalite

Lab results

1.9 kg/ltr		Zement 2	MF 55.5%	◀	▶		LOT	R1B1	Rheology	
<i>per mt Cement</i>		<i>Code</i>	<i>Name</i>	<i>pro 1.0 m³</i>					T1 22 °C	
555.2	lt	FRWA	Fresh water	553.4	lt		Bohrung	3 rpm	18.5	
1.0	lt	CAF_902	Antifoam	1.0	lt			6 rpm	22.0	
1.5	kg	CDI_213	Dispersant	1.5	kg			30 rpm	39.0	
								60 rpm	47.5	
								100 rpm	56.5	
								200 rpm	77.0	
								300 rpm	91.5	
								600 rpm	143.0	
								TT		100Bc 216 min
								FL		
1350.0	kg	HT- Blend 35%	Cement	1.3	ton		Bohrung	FF		
1003.2	ltr	Yield						CS		

High-Temperature Stability: Thermalite

Equipment on site



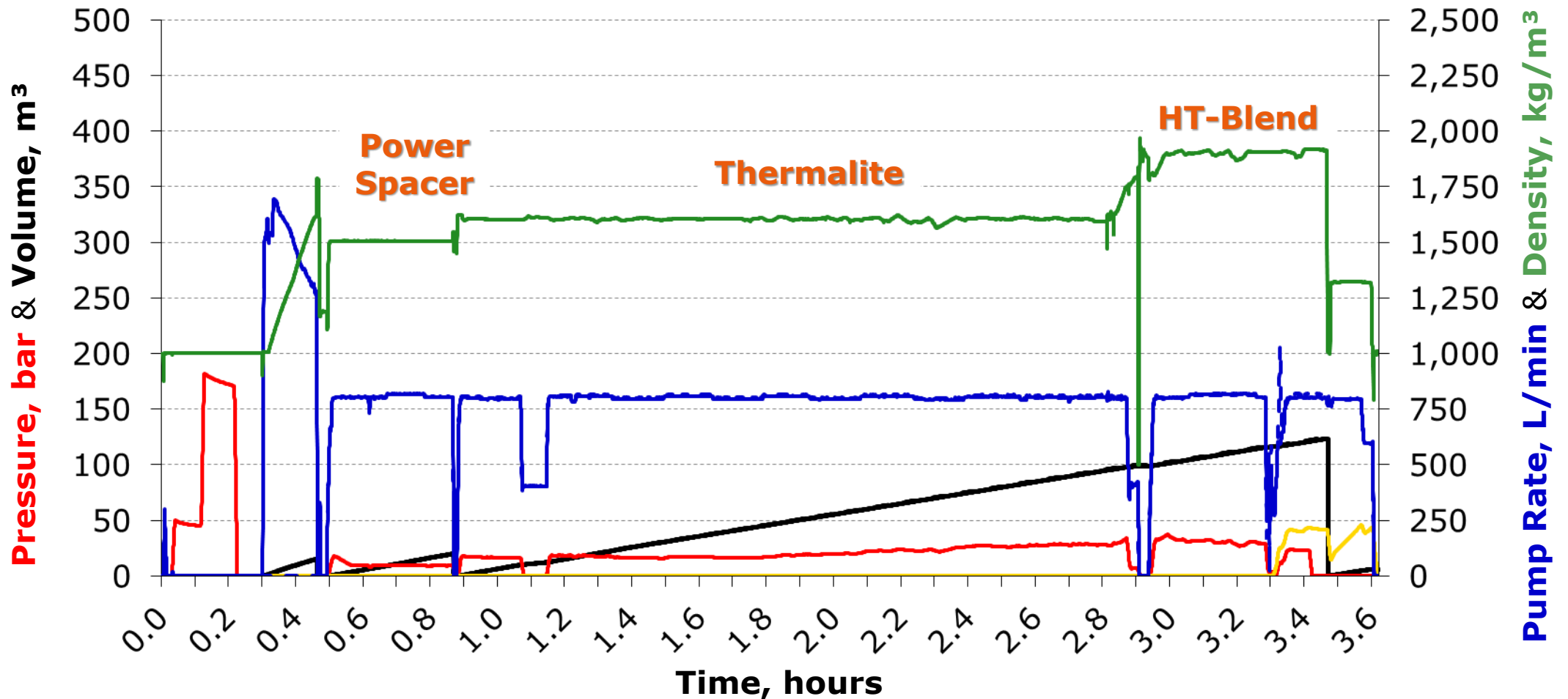
High-Temperature Stability: Thermalite

Pumping schedule

Step	Volume, m ³	Density, kg/L	Pump Rate, L/min
Pressure test			
Pump fresh mud pill with low YP (rig)	20.0		
Pump Power Spacer	20.0	1.40	900
Mix & pump lead slurry until cement comes to surface	130.0	1.60	800
Mix & pump tail slurry	30.0	1.90	800
Pump Power Spacer	1.0	1.40	800
Pump mud	7.0	1.25	800

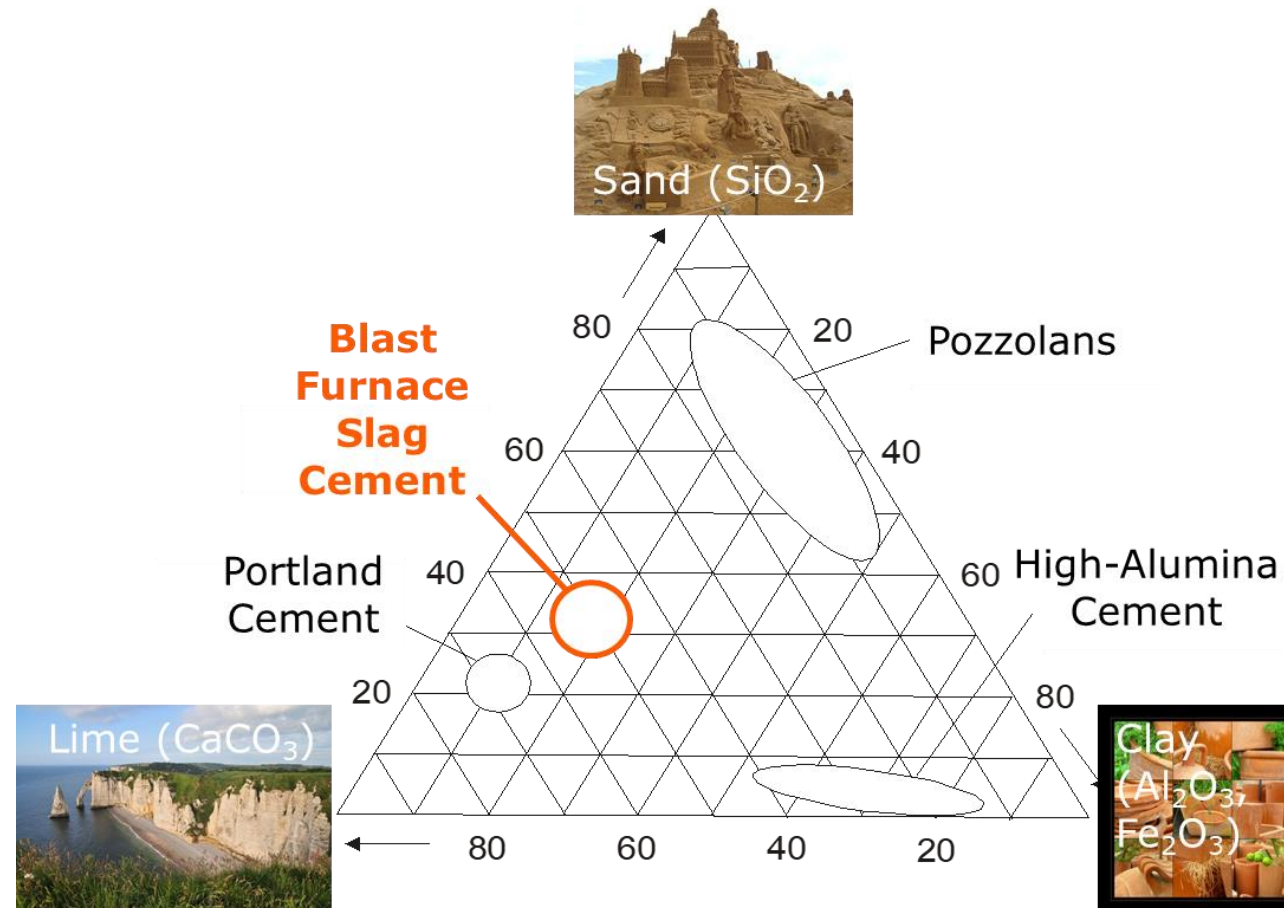
High-Temperature Stability: Thermalite

Pumping schedule



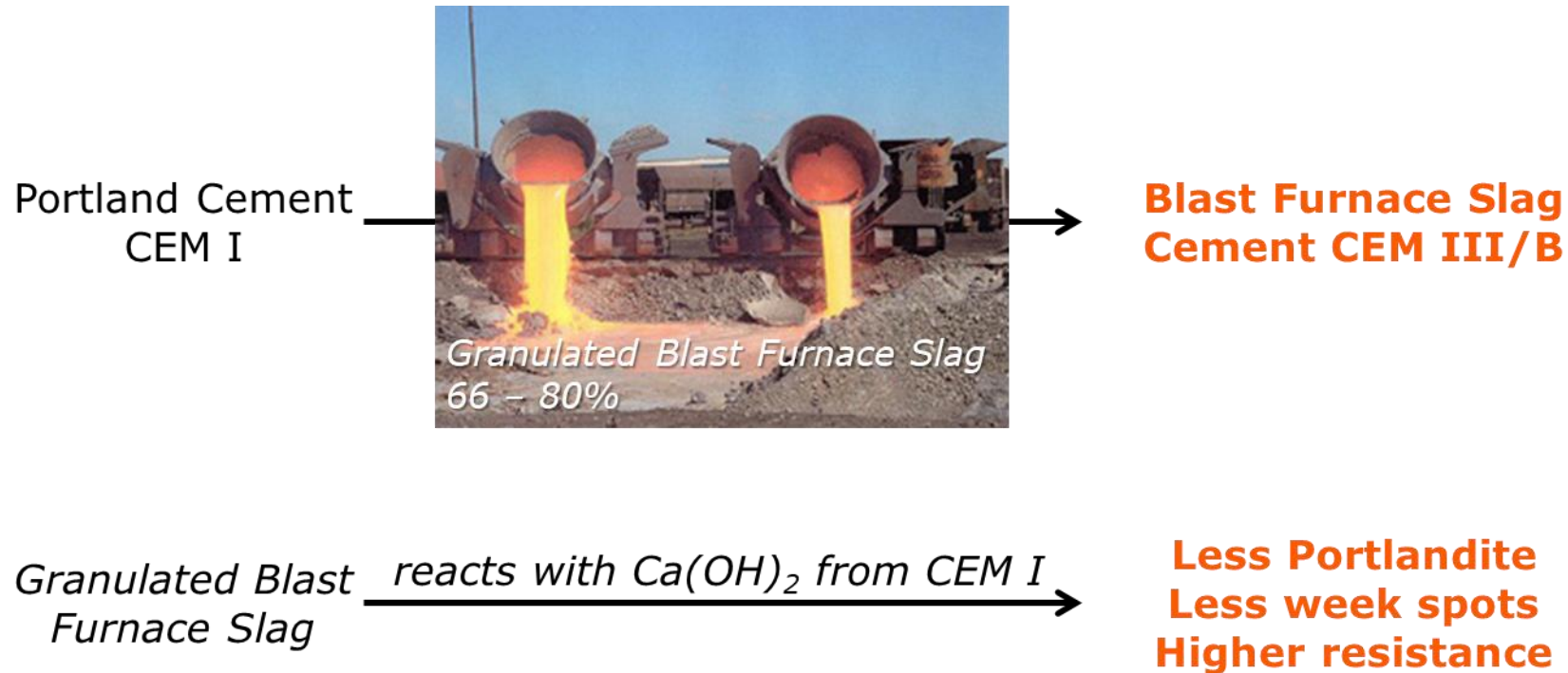
Blast Furnace Slag Cement-based Systems

Addition of latent hydraulic material (DIN EN 197-1)



Blast Furnace Slag Cement-based Systems

Addition of latent hydraulic material (DIN EN 197-1)



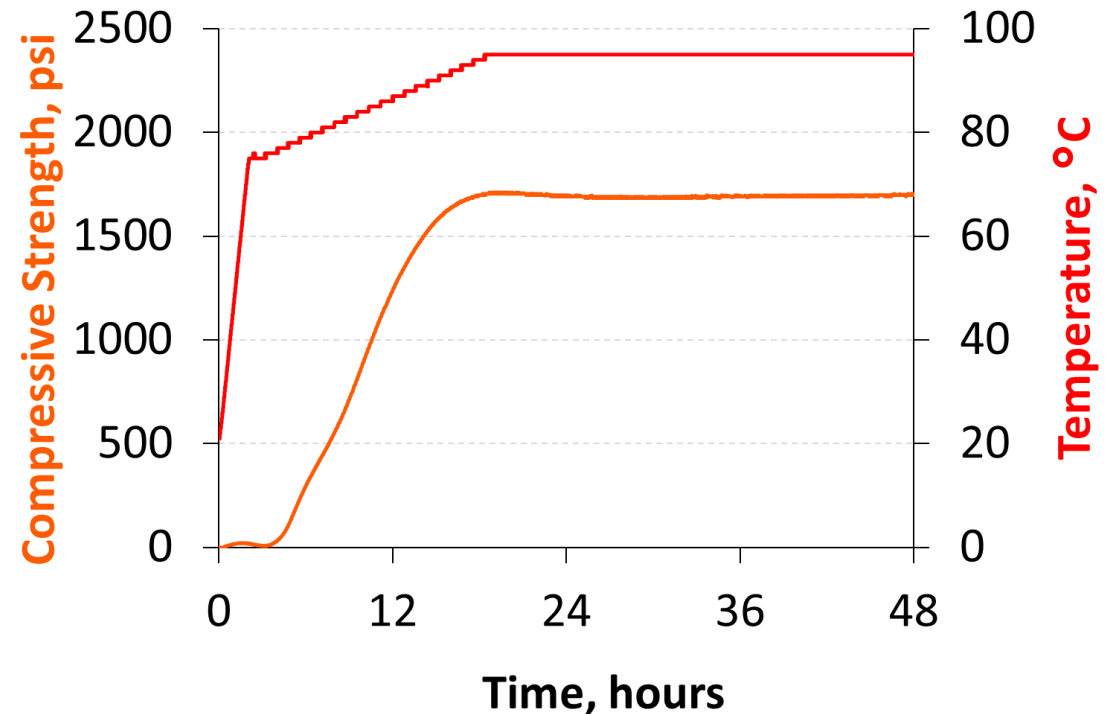
HOZlite: Light-Weight System for Weak Formations

Lab results

HOZlite

Young's Modulus, GPa	4.77
Poisson's Ratio	0.22
Density Range, kg/L	1.35 – 1.40
Thermal Conductivity, W/m·K	0.8

Ideal for Cementing GRE-Material



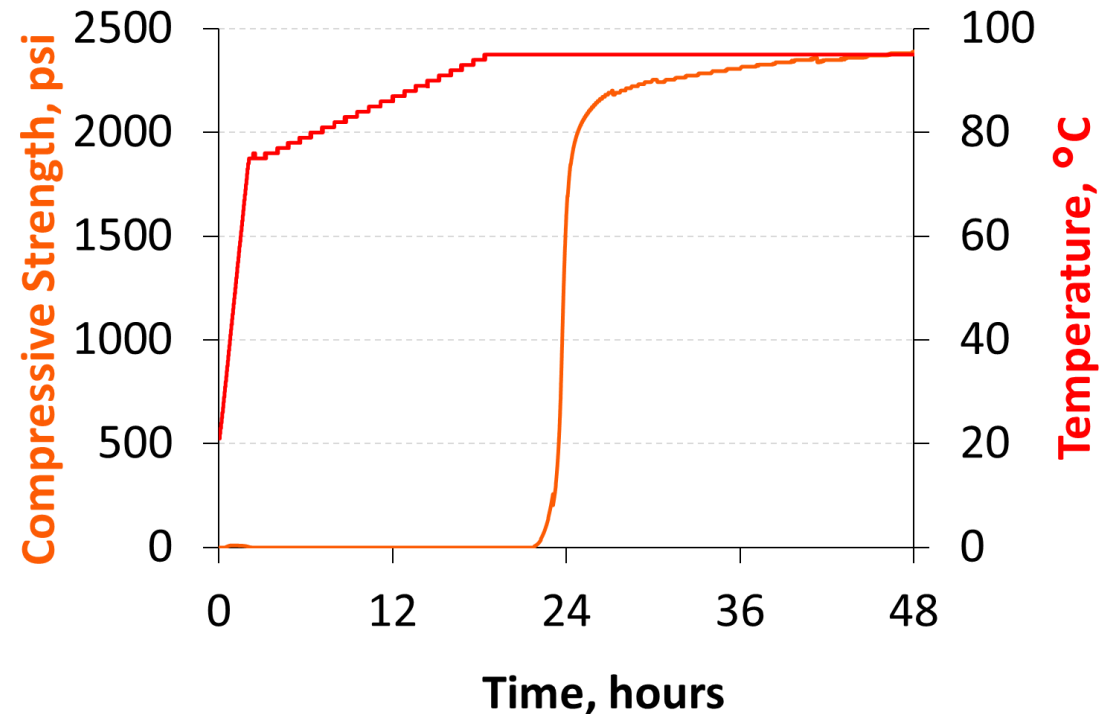
HMR+ Blend: CO₂-Resistance and H₂-Tightness

Lab results

HMR+ Blend

Permeability against Brine, mD	$4.4 \cdot 10^{-7}$
Permeability against H ₂ , mD	$2.2 \cdot 10^{-8}$
Typical Density, kg/L	1.88
CaO / SiO ₂ -Ratio	0.8

Well-Established for P&A-Applications



Cementing Geothermal Wells in NL: HOZlite and HMR+ Blend

Equipment on site



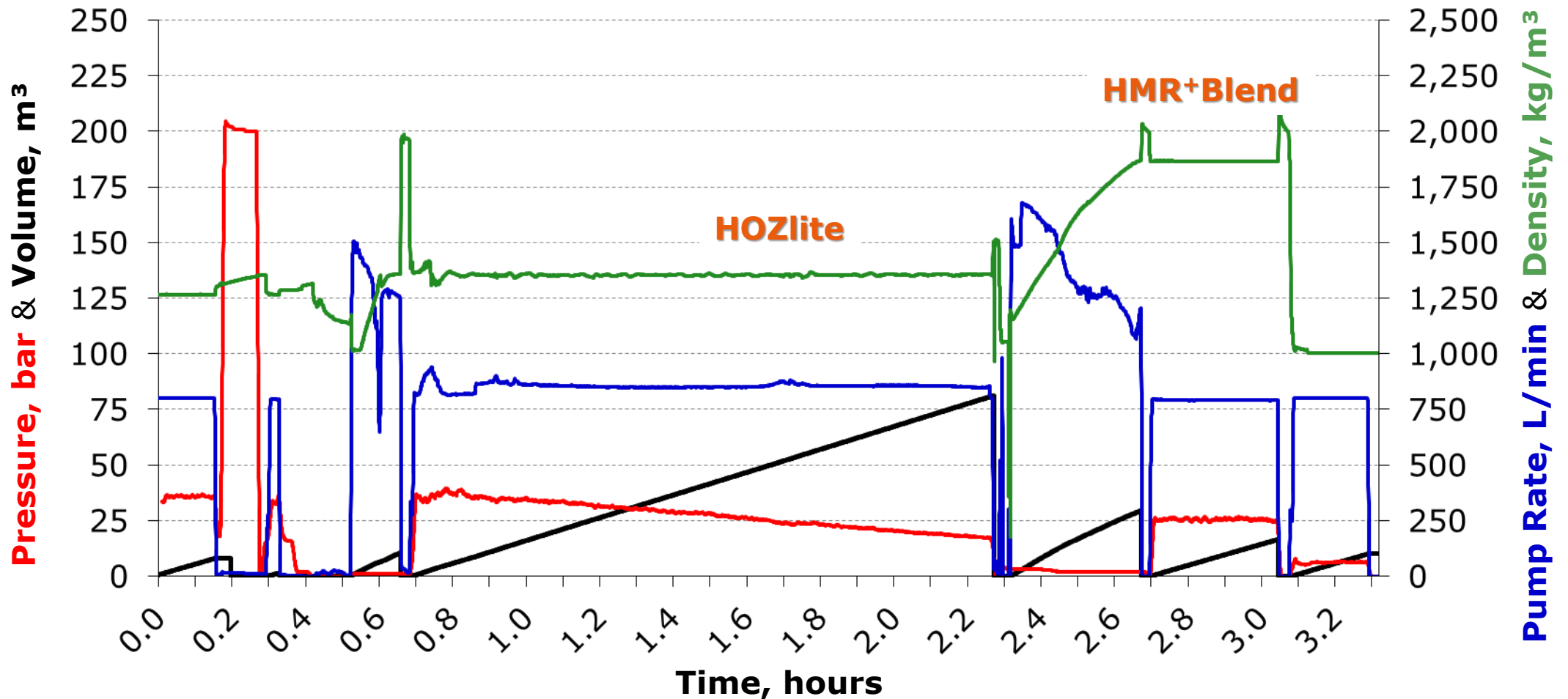
Cementing Geothermal Wells in NL: HOZlite and HMR+ Blend

Pumping schedule

Step	Volume, m ³	Density, kg/L	Pump Rate, L/min
Pressure test			
Pump spacer	1.5	1.25	800
Mix & pump lead slurry	80.0	1.35	800
Mix & pump tail slurry	16.0	1.88	800
Displace with water	10.0	1.00	800

Cementing Geothermal Wells in NL: HOZlite and HMR+ Blend

Pumping schedule



Cementing with Hydraulic Stage Tool: HMR+ Blend and API Class G

Lab results

1,28 kg/ltr <i>pro 1m³ Spacer</i>		Spacer <i>Code</i>	Spacer <i>Name</i>	◀ ▶ <i>pro 1.0 m³</i>		LOT	Bemerkung	R1B1	Rheologie	
									T1 22 °C	T2 80 °C
832.4	ltr	FRWA	Frischwasser	832.39	ltr			3 rpm	12	10
2.0	kg	SGL_312	Spezial	2.00	kg			6 rpm	13.5	11
1.50	kg	CDI_290	Verflüssiger	1.50	kg			30 rpm	18.5	15.5
446.61	kg	CWA_705	Schwerstoff	446.61	kg			60 rpm	19	16.5
								100 rpm	20.5	18.5
								200 rpm	38.5	31
								300 rpm	45	34.5
								600 rpm	59	43
1000.0	ltr	Ergiebigkeit								

Cementing with Hydraulic Stage Tool: HMR+ Blend and API Class G

Lab results

1,6 kg/ltr		Step 1	MF 68.7%	◀	▶		LOT	Bemerkung	R1B1	Rheologie	
pro mt Zement		Code	Name	pro 1.0 m ³						T1 22 °C	T2 80 °C
1134.8	ltr	FRWA	Frisch Wasser	650.33		ltr			3 rpm	8.5	10.5
2.0	ltr	CAF_902	Entschäumer	1.15		ltr			6 rpm	9	12
5.00	kg	CXT_621	Extender	2.87		kg			30 rpm	10.5	16
1.00	kg	CFL_380	FluidLoss	0.57		kg			60 rpm	11.5	17.5
124.46	kg	CSL_944	Salz	71.32		kg			100 rpm	13.5	19
3.50	kg	CRE_120	Verzögerer	2.01		kg			200 rpm	18	23
10.00	kg	CXP_320	Expander	5.73		kg			300 rpm	24	25.5
									600 rpm	41	39
									10min Gel		
									TT	POD 270 min	70Bc 285 min
									FL		
1515.15	kg	HMR+	Zement	0.87		ton			FF		
1745.0	ltr	Ergiebigkeit							CS	500psi at 16 hr	24hr 3250psi

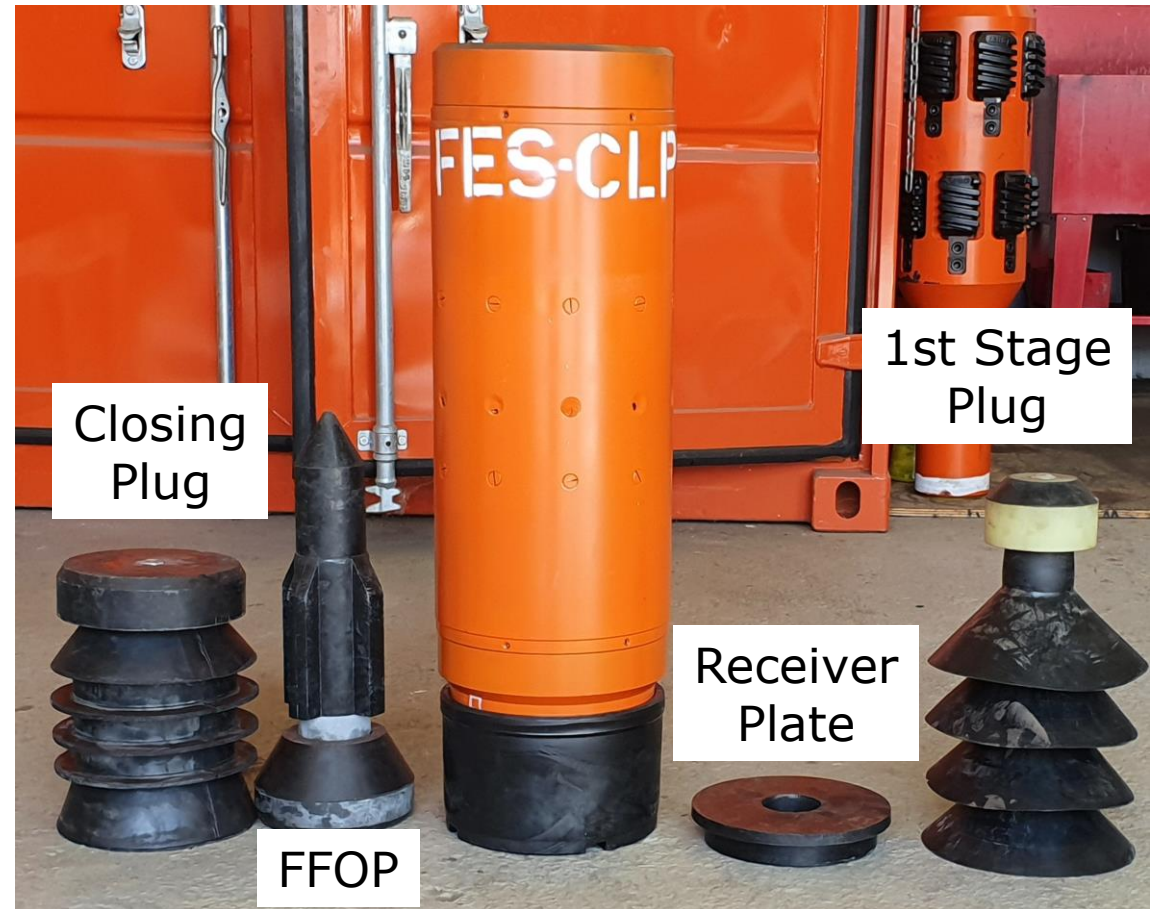
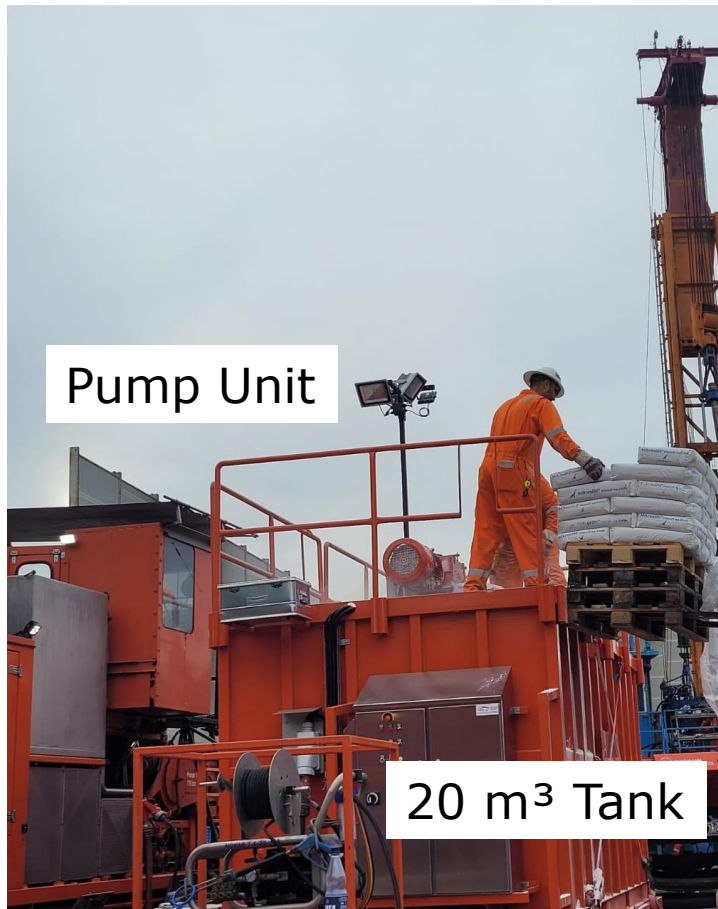
Cementing with Hydraulic Stage Tool: HMR+ Blend and API Class G

Lab results

1,6 kg/ltr		Step 2	MF 73.1%	◀	▶		LOT	Bemerkung	R1B1	Rheologie	
pro mt Zement		Code	Name	pro 1.0 m ³						T1 22 °C	T2 80 °C
841.6	lt	FRWA	Frischwasser	721.43	lt				3 rpm	10	10.5
1.0	lt	CAF_902	Entschäumer	0.86	lt				6 rpm	12	12.5
15.00	kg	CXT_621	Extender	12.86	kg				30 rpm	17	25
1.00	kg	CFL_380	FluidLoss	0.86	kg				60 rpm	17.5	25.5
0.50	kg	CRE_120	Verzögerer	0.43	kg				100 rpm	18	26.5
10.00	kg	CXP_320	Expander	8.57	kg				200 rpm	20	27.5
									300 rpm	22.5	28
									600 rpm	34	34
									10min Gel		
									TT	POD 190 min	70Bc 225 min
									FL		
1000.00	kg	API Class G	Zement	0.86	ton				FF		
1166.6	ltr	Ergiebigkeit							CS		

Cementing with Hydraulic Stage Tool: HMR⁺ Blend and API Class G

Equipment on site



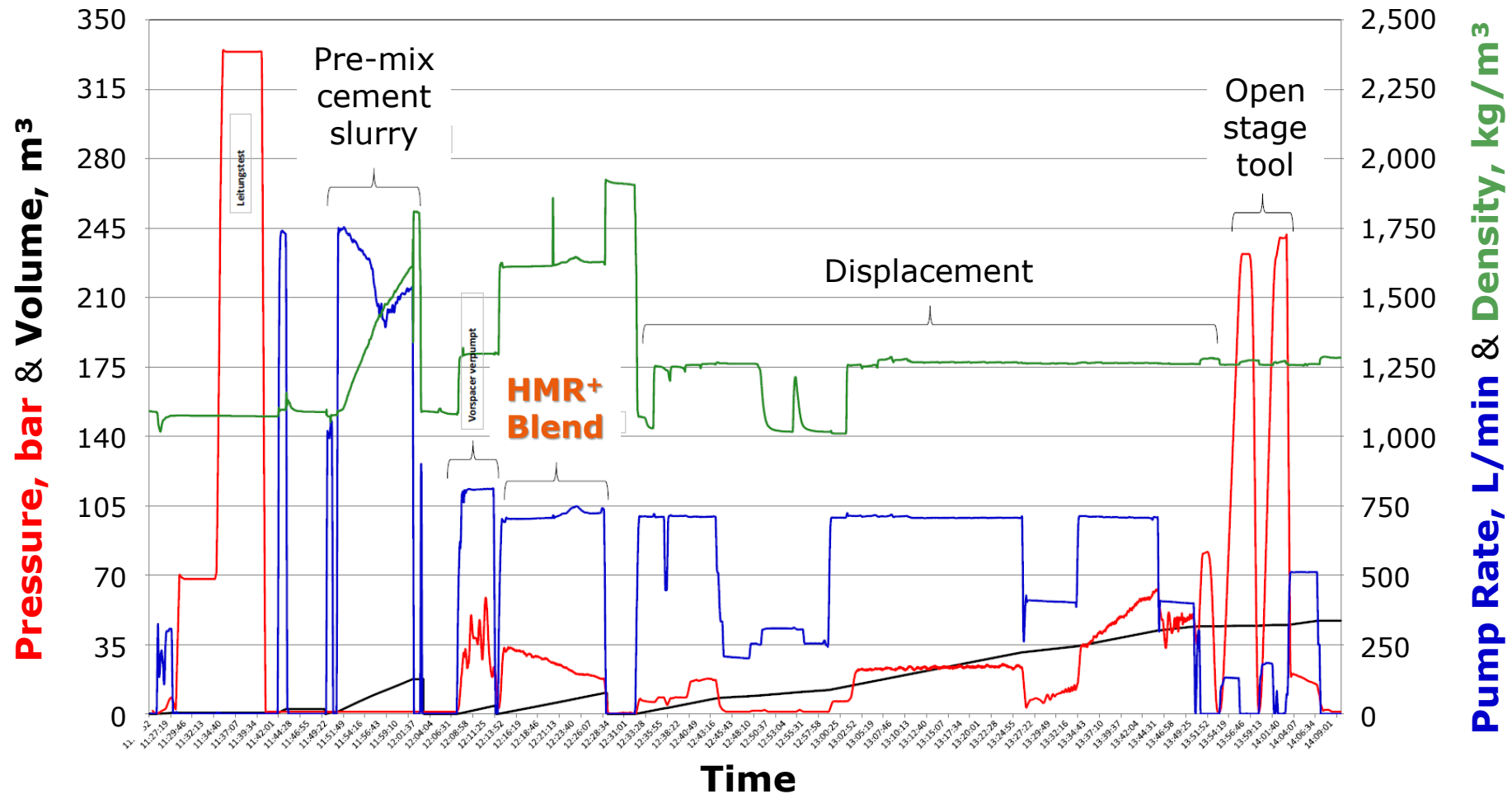
Cementing with Hydraulic Stage Tool: HMR⁺ Blend and API Class G

Pumping schedule step 1

Step	Volume, m ³	Density, kg/L	Pump Rate, L/min
Pressure tests			
Pump spacer	4.0	1.28	800
Mix and pump HMR ⁺ Blend slurry	10.5	1.60	700
Release 1 st stage plug			
Pump fresh-water spacer	1.5	1.00	700
Pump mud	8.6	1.23	700
Pump fresh-water spacer	4.5	1.00	700
Pump mud	28.7	1.23	700
Pressure build-up after landing of 1 st stage plug			
Open stage tool (hydraulic)			

Cementing with Hydraulic Stage Tool: HMR+ Blend and API Class G

Pumping schedule step 1



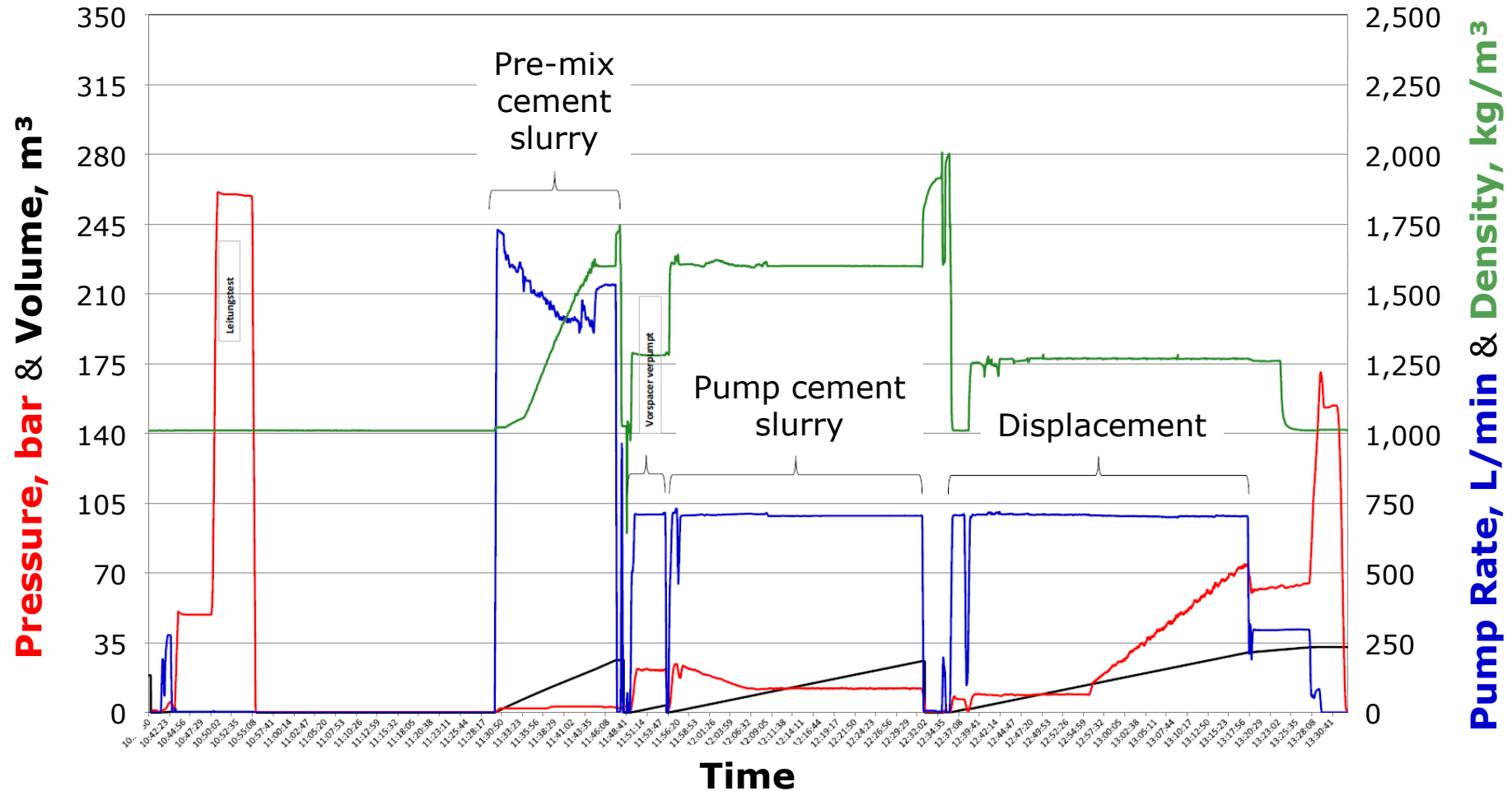
Cementing with Hydraulic Stage Tool: HMR⁺ Blend and API Class G

Pumping schedule step 2

Step	Volume, m ³	Density, kg/L	Pump Rate, L/min
Pressure tests			
Pump spacer	3.5	1.28	800
Mix and pump API Class G slurry	25.2	1.60	700
Release closing plug			
Pump cement slurry	0.5	1.60	700
Pump fresh-water spacer	1.5	1.00	700
Pump mud	30.3	1.23	700
Close stage tool after landing of plug			
Flow check			

Cementing with Hydraulic Stage Tool: HMR+ Blend and API Class G

Pumping schedule step 2



Innovative Systems for Cementing Geothermal Wells

Summary

- ✓ Abrasive **Power Spacer** for excellent well preparation
- ✓ **Thermalite**: Mechanical optimized temperature-stable system
- ✓ **HMR+ Blend** for CO₂-resistance and H₂-tightness
- ✓ Cementing weak formations employing **HOZlite**
- ✓ In-house blending and quality control
- ✓ Well-established recipes for premium cement quality



Ready for Service

For clarification, please contact me directly

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