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Innovative Fluid System for Dissolving Lead Scales in Geothermal Wells

DGK

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Dr. Nils Recalde Lummer and Tobias Willert

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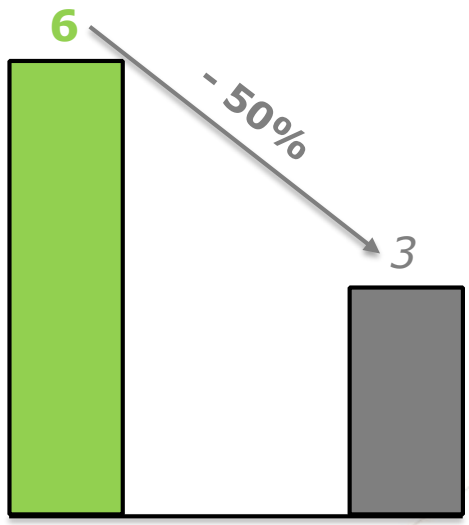
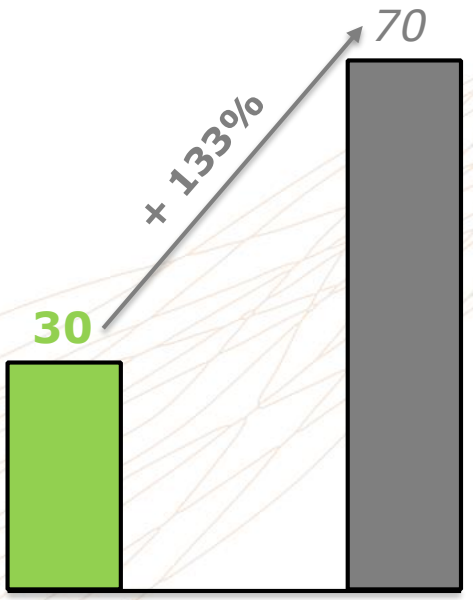
Introduction, Lab Testing and Facility Trials

Decrease in Injectivity

Initial and *actual*

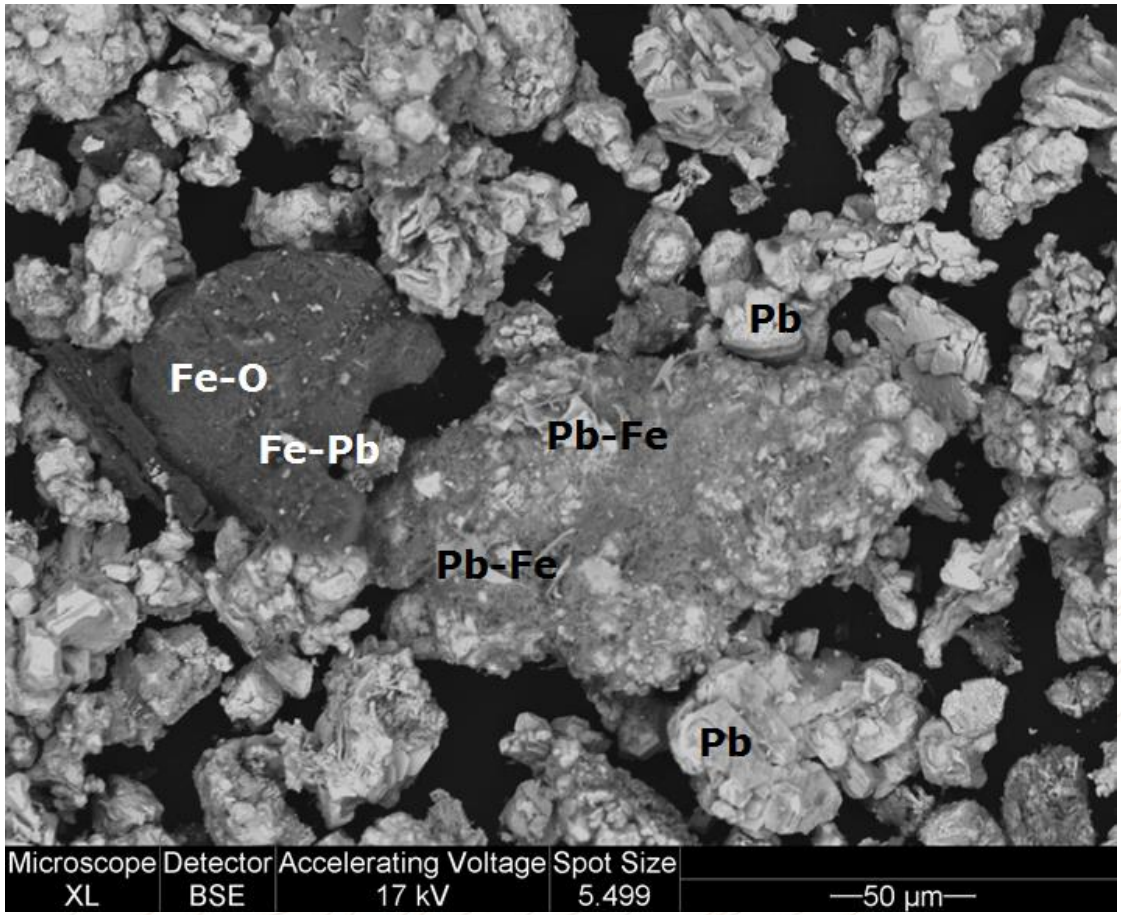


Injection Rate, m³/min



Injection Pressure, bar

Lead-Scale Sample



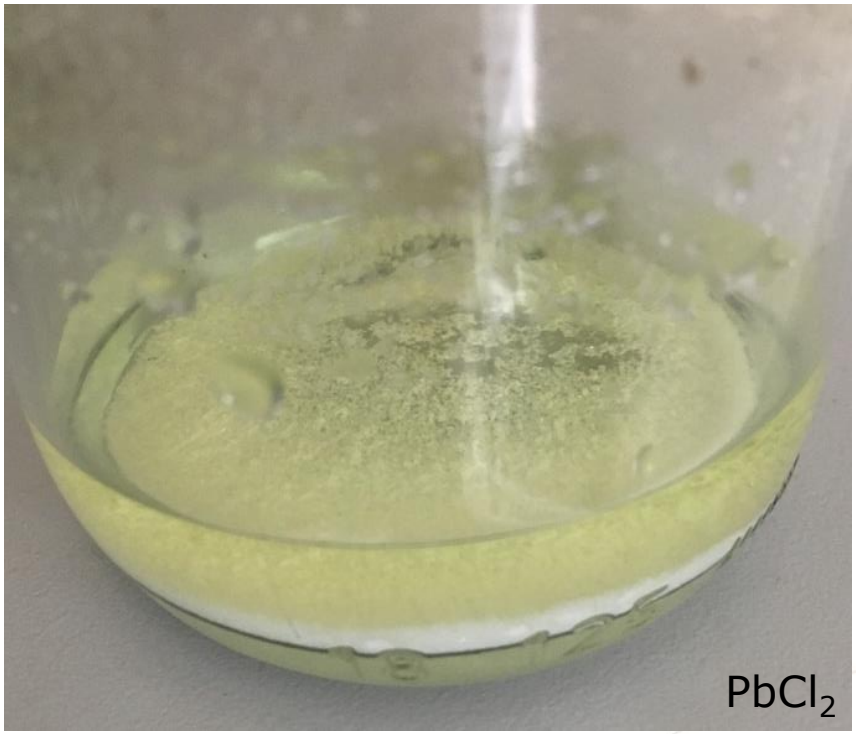
Fluid Recipes for Solubility Tests

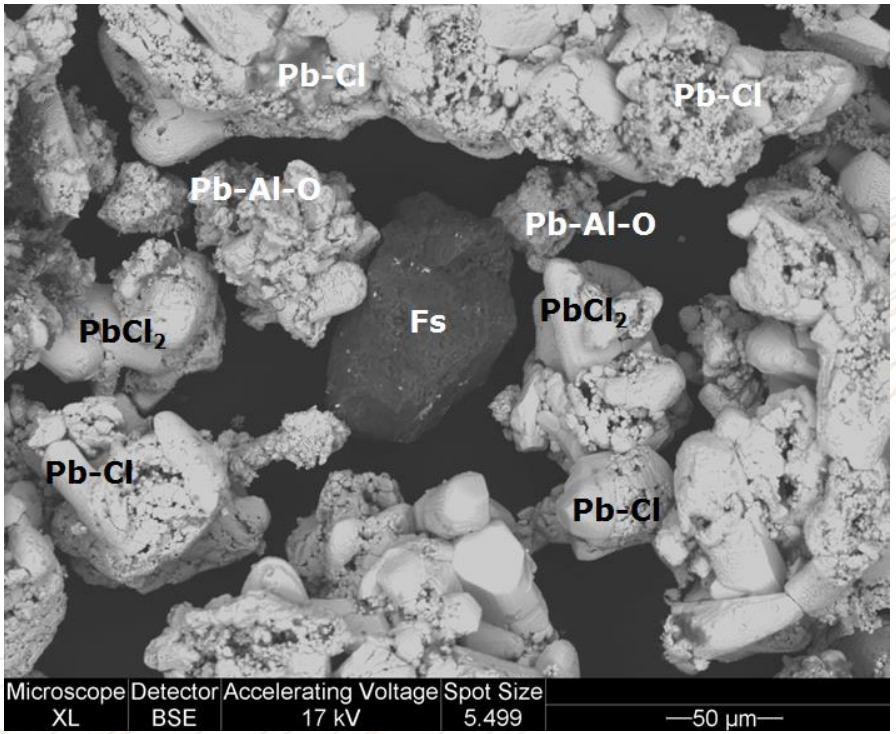
#	Composition	Function
1	15% HCl	Strong inorganic acid (pH=0)
2	20% SSB-007	Strong organic acid system (pH=0)
3	10% SAC-085	Weak organic acid (pH=0)
4	H_2O + 25 kg/m³ SBR-510	Oxidizing breaker (pH=4)
5	H_2O + 25 kg/m³ STB-502	Salt for pH-control (pH=12)
6	50% SSD-651	Strong chelating agent (pH=12)

Results of Solubility Tests

#	Composition	Pb-Scale Dissolved, wt.%
1	15% HCl	65
2	20% SSB-007	31
3	10% SAC-085	28
4	H_2O + 25 kg/m³ SBR-510	Scale Formation
5	H_2O + 25 kg/m³ STB-502	27
6	50% SSD-651	Scale Formation

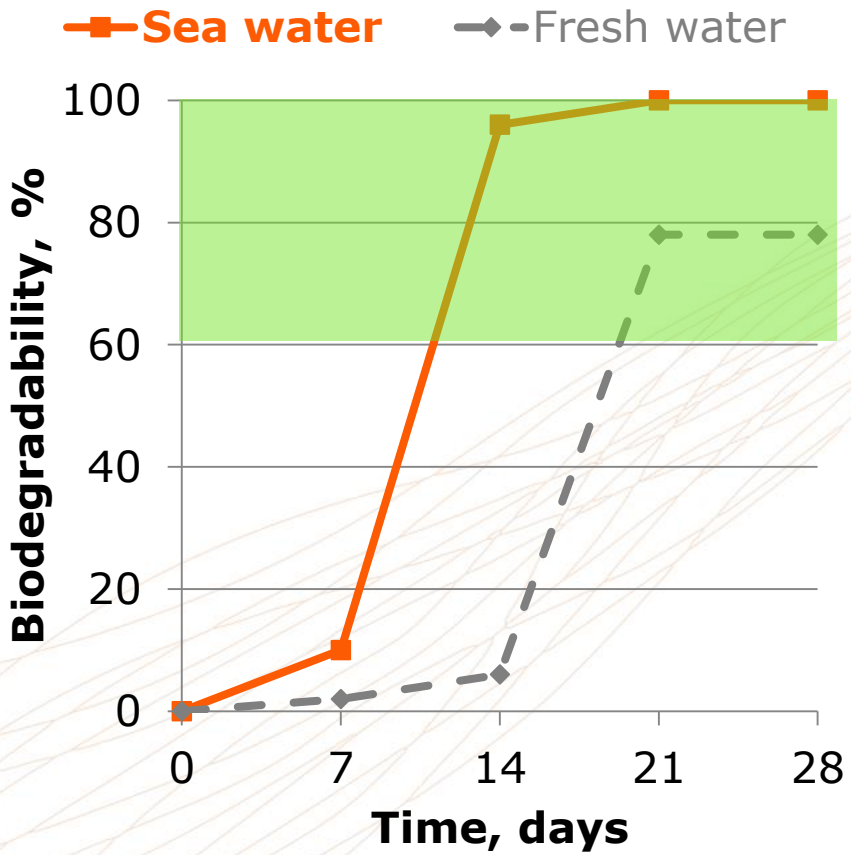
Incompatibility with HCl





SSB-007

- ✓ Low toxicity to aquatic life; WGK-1 classified formulation
- ✓ Odor-free / evolves no dangerous volatiles
- ✓ Low corrosivity, even at elevated temperatures
- ✓ Based upon a readily biodegradable organic acid

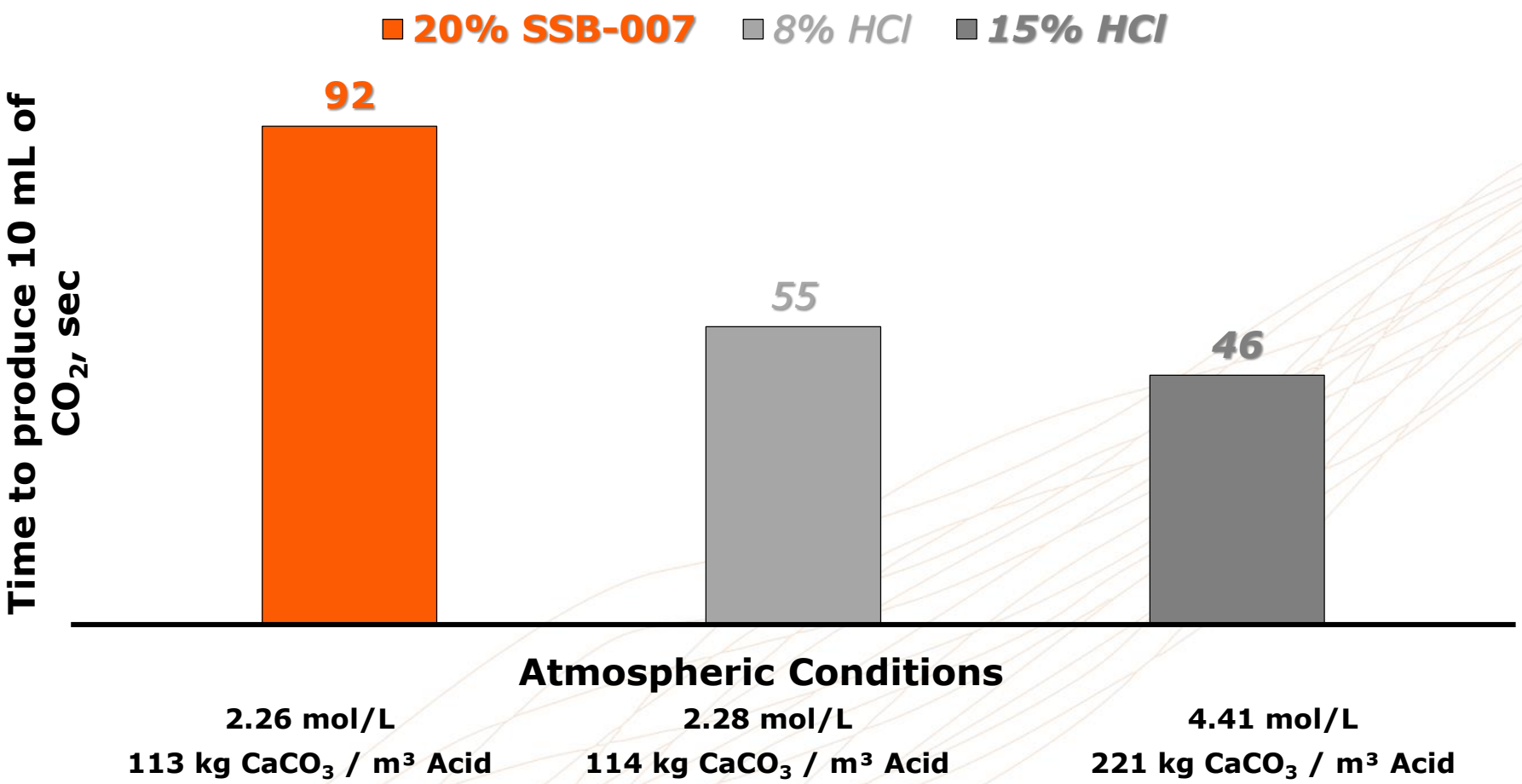


Premium Descaling

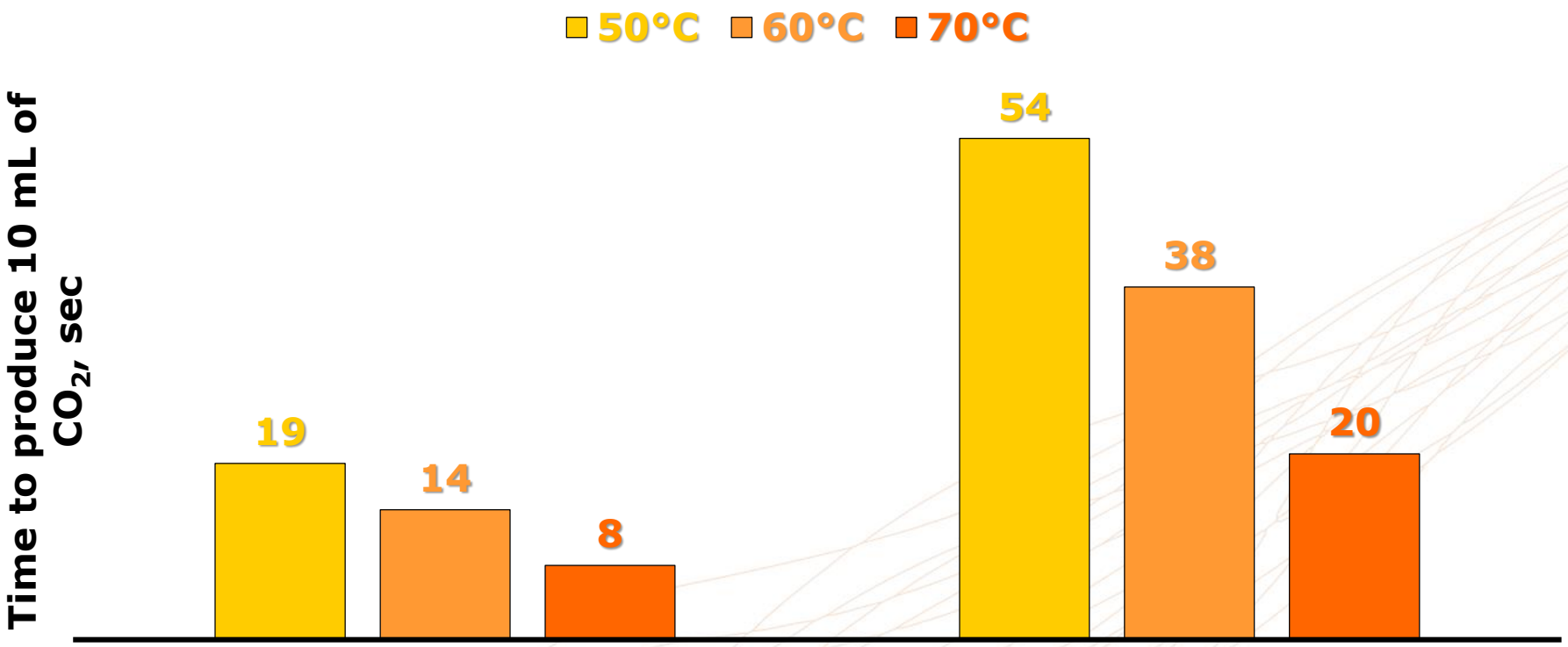
Naturally Retarded Reactivity with Carbonates

Time to produce 10 mL of **CO_2**

Naturally Retarded Reactivity with Carbonates



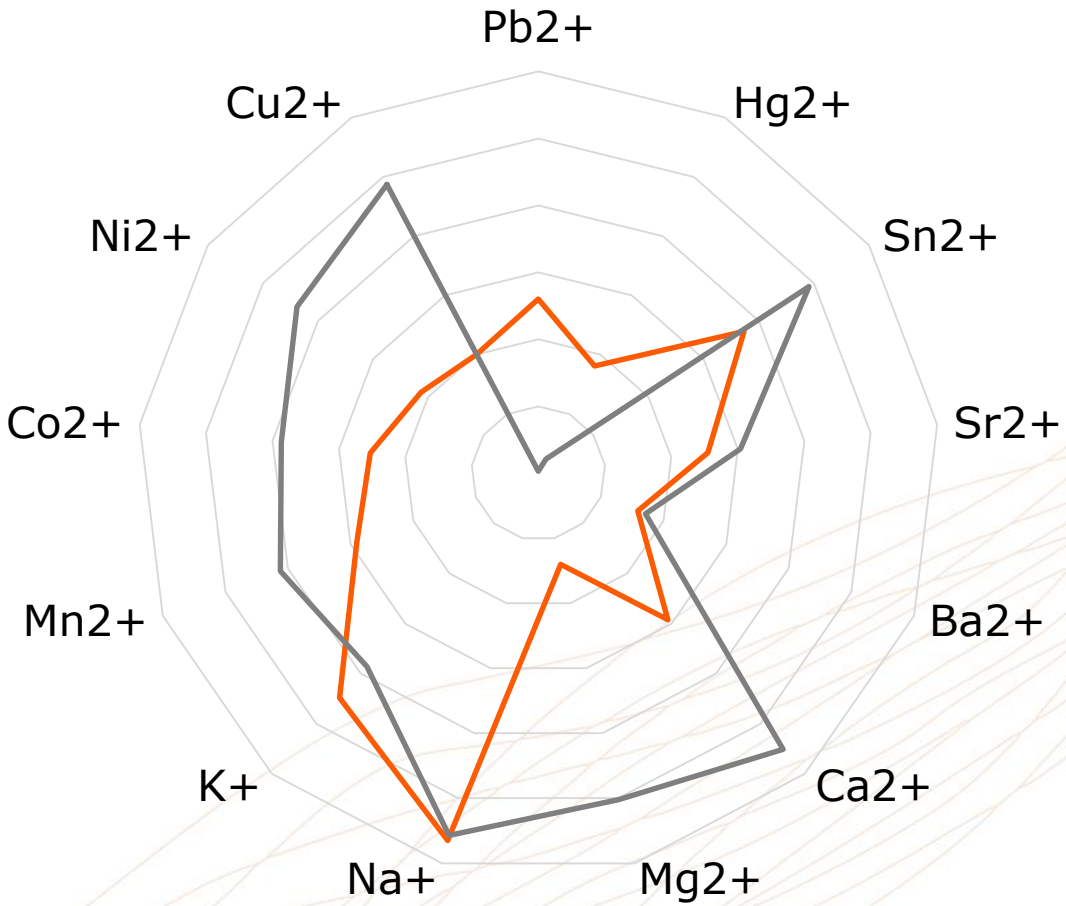
Comparison with Weak Organic Acid SAC-085



Low Corrosion Tendency

Fluid + 10 L/m³ corrosion inhibitor + 1 kg/m³ intensifier	Corrosion rate for L-80 after 6 hours @ 150°C
15% HCl	*0.069 lbs/ft²*
8% HCl	*0.024 lbs/ft²*
20% SSB-007	**0.005 lbs/ft²**

Relative Solubility of Metal-Ions in *HCl* / SSB-007

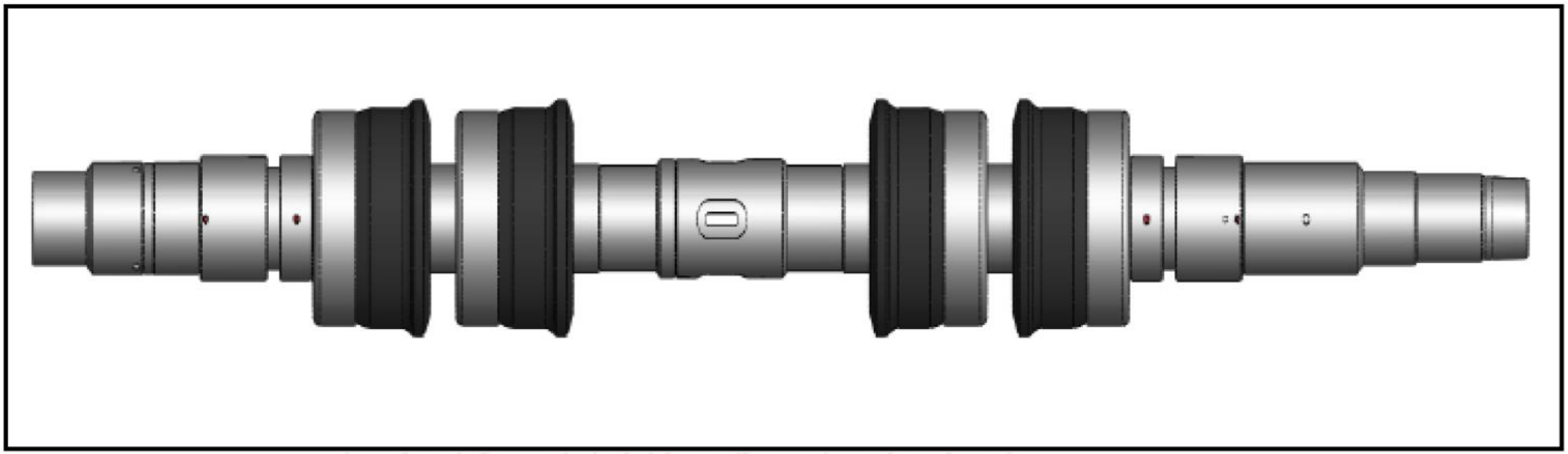


Results of Solubility Tests

#	Composition	Pb-Scale Dissolved, wt.%
1	15% HCl	65
2	**20% SSB-007**	**31**
3	10% SAC-085	28
4	H_2O + 25 kg/m³ SBR-510	Scale Formation
5	**H_2O + 25 kg/m³ STB-502**	**27**
6	50% SSD-651	Scale Formation

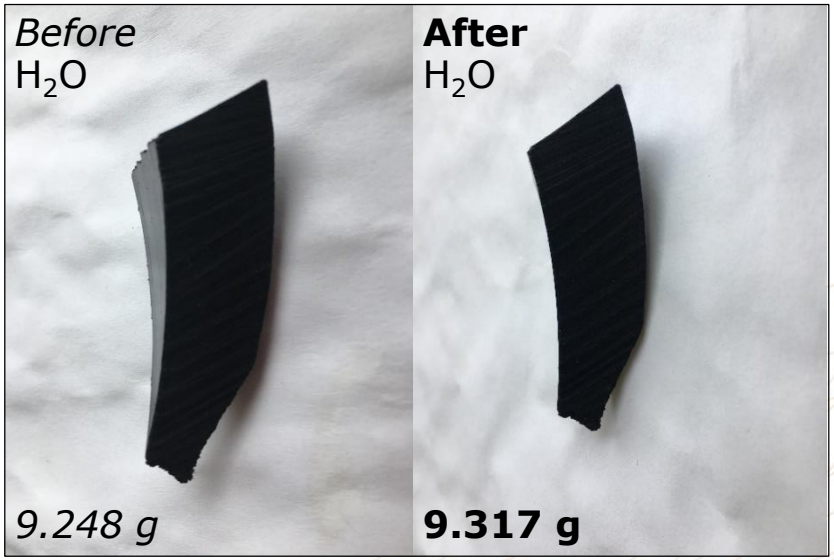
Advantage of a Step-wise Application

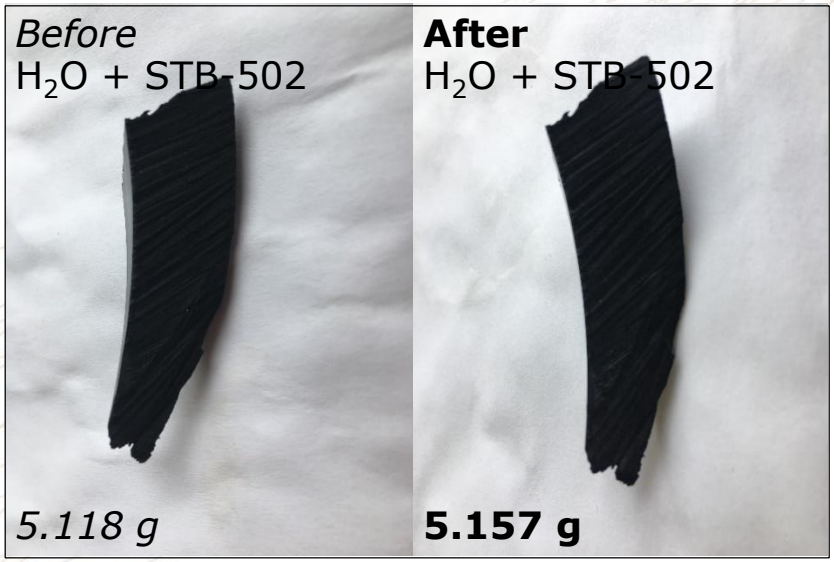
#	Step 1	Step 2	Pb-Scale Dissolved, wt.%
7	**STB-502**	**20% SSB-007**	**38**
8	STB-502	10% SAC-085	36



Compatibility of Nitrile

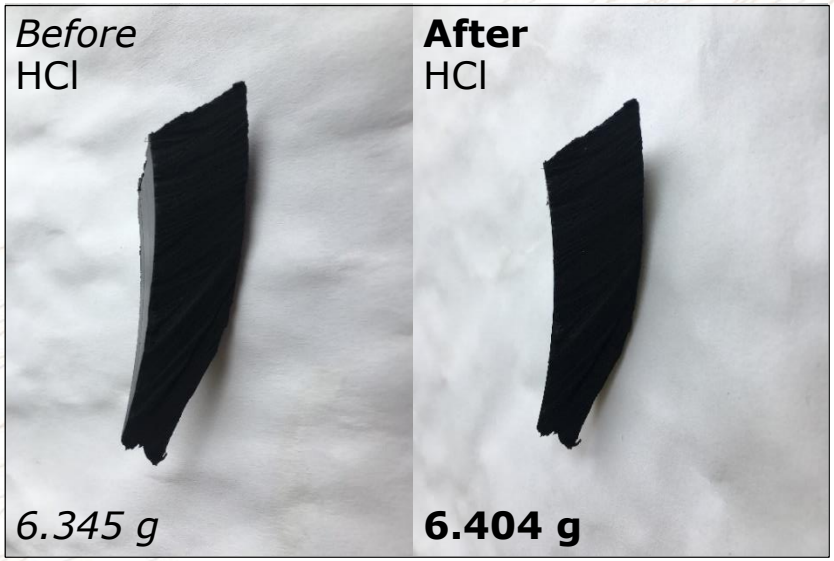
Fluids	Increase in weight of Nitrile after 40 hours @ 63°C, wt%
H_2O	0.7
H_2O + 25 kg/m³ STB-502	0.8





Compatibility of Nitrile

Fluids	Increase in weight of Nitrile after 40 hours @ 63°C, wt%
SSB-007 (20%)	0.8
HCl (15%)	0.9



Composition of Formation Water

Element/Ion	Concentration, mg/L
Sodium, Na^+	54,000*
Calcium, Ca^{2+}	23,600*
Magnesium, Mg^{2+}	2,910*
Chloride, Cl^-	137,000**

* Prepared through dissolving appropriate amounts of NaCl, $CaCl_2$, and $MgCl_2 \cdot 6H_2O$ in deionized water. Diluted HCl for pH adjustment to 6.0

** As confirmed by photometry

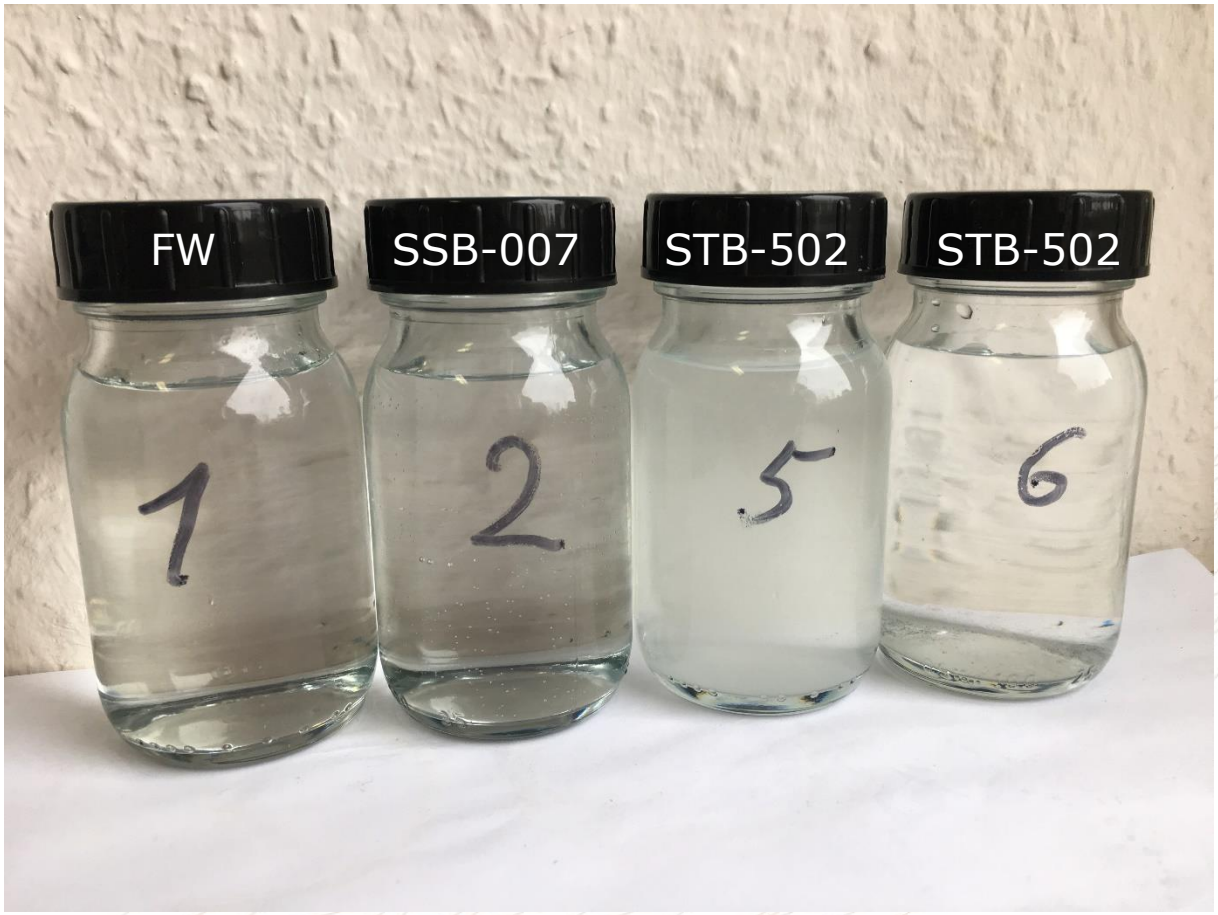
Compatibility Tests with Formation Water

Beaker	Content	Ratio
1	Formation Water (FW)	90 mL / 0 mL
2	FW + Fluid 1*	45 mL / 45 mL
5	FW + Fluid 2**	85 mL / 5 mL
6	FW + Fluid 2**	89 mL / 1 mL

* Fluid 1: SSB-007 (20%) = Step 2

** Fluid 2: H_2O + 25 kg/m³ STB-502 = Step 1

Compatibility with Formation Water @ 22°C



Compatibility with Formation Water @ 22°C

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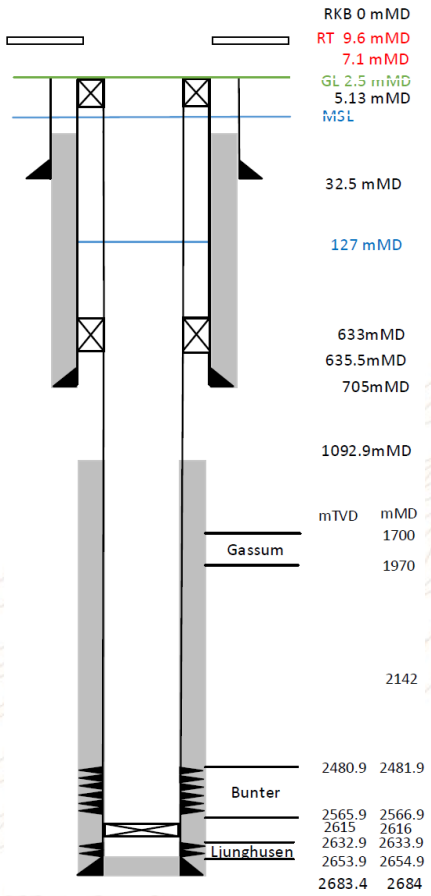
Field Trial

Field Trial in Bunter Formation

Zone	Length, m	Wash Interval	Top, TVD m	Bottom, TVD m
1	3.5			
Blank	3.5	1	2520	2540
2	10.5			
Blank	2.5			
3	9.0	2	2500	2520
Blank	11.5			
4	2.0			
Blank	41.0	3	2480	2500



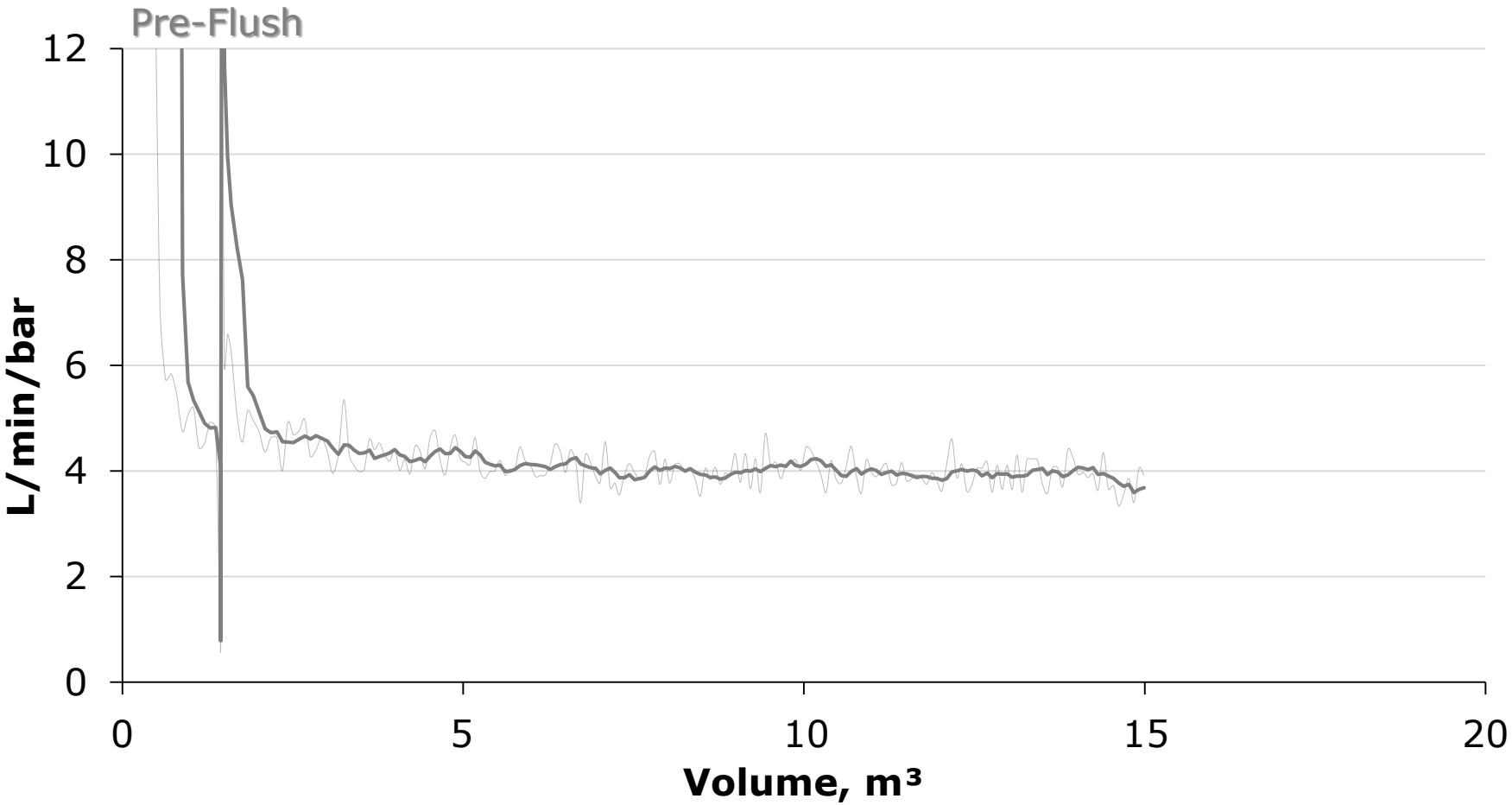
Pumping Plan

Zone	Length, m	Wash Interval	Pre-Flush (brine), m³	STB-502, m³	Displacement (brine), m³	SSB-007, m³	Displacement (brine), m³	Over-Flush (brine), m³
1	3.5							
Blank	3.5	1	15.0	2.7	10.0	4.0	10.0	20.2
2	10.5							
Blank	2.5							
3	9.0	2	15.0	1.7	10.0	2.6	10.0	13.0
Blank	11.5							
4	2.0	3	15.0	0.4	10.0	0.6	10.0	2.9
Blank	41.0							

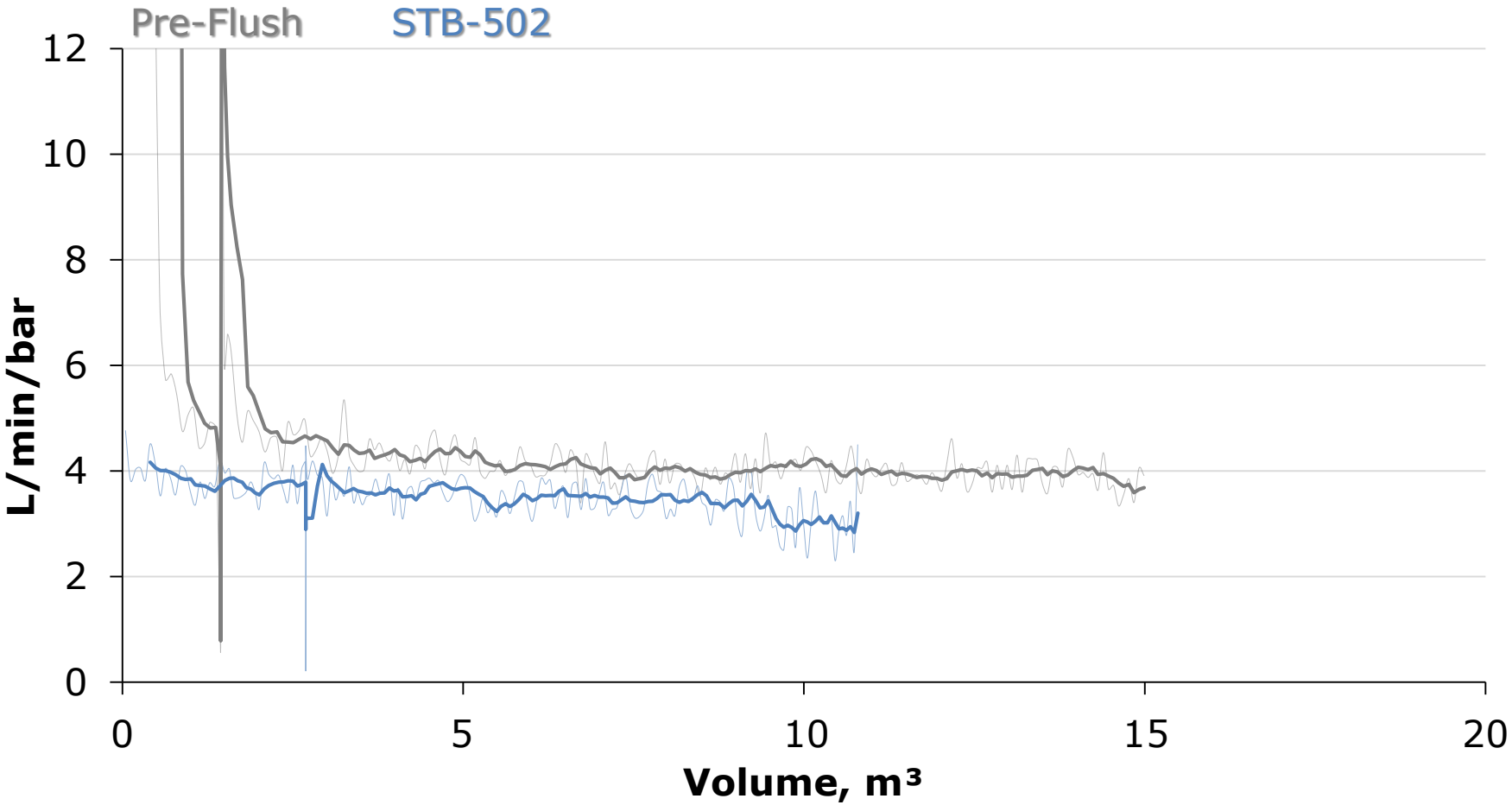
Equipment on Site

Equipment on Site

Results for Wash Interval 1



Results for Wash Interval 1



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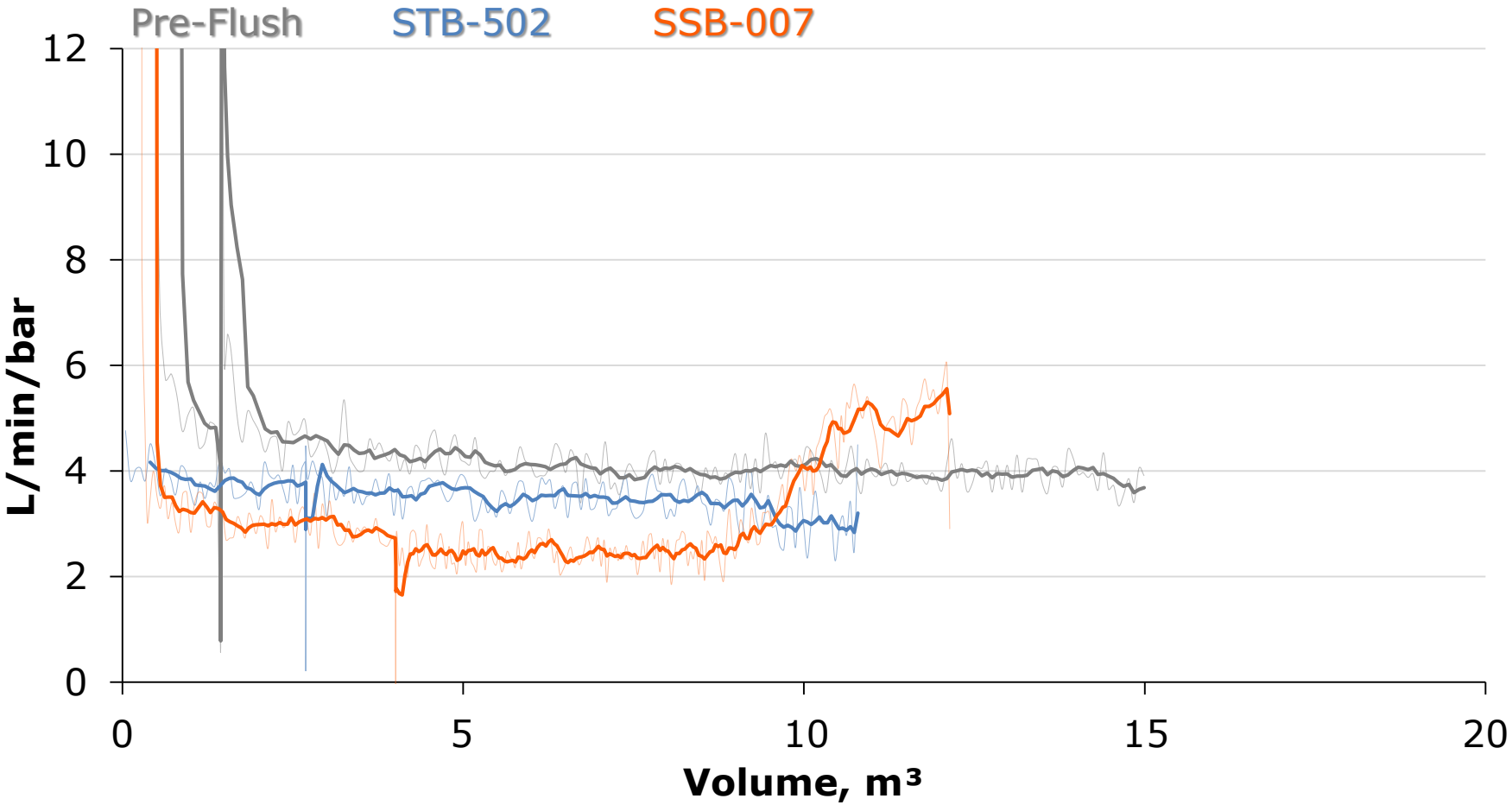
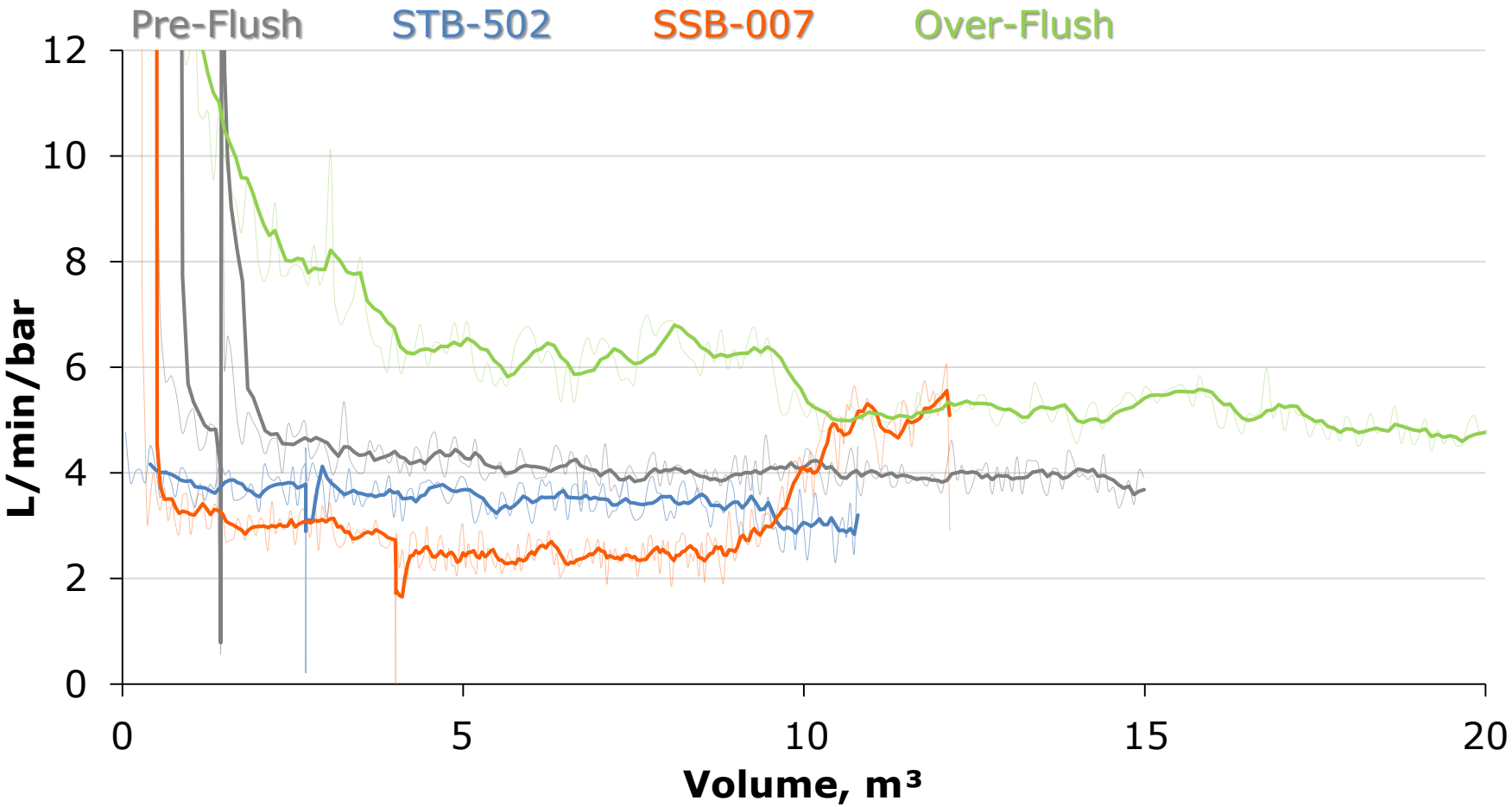
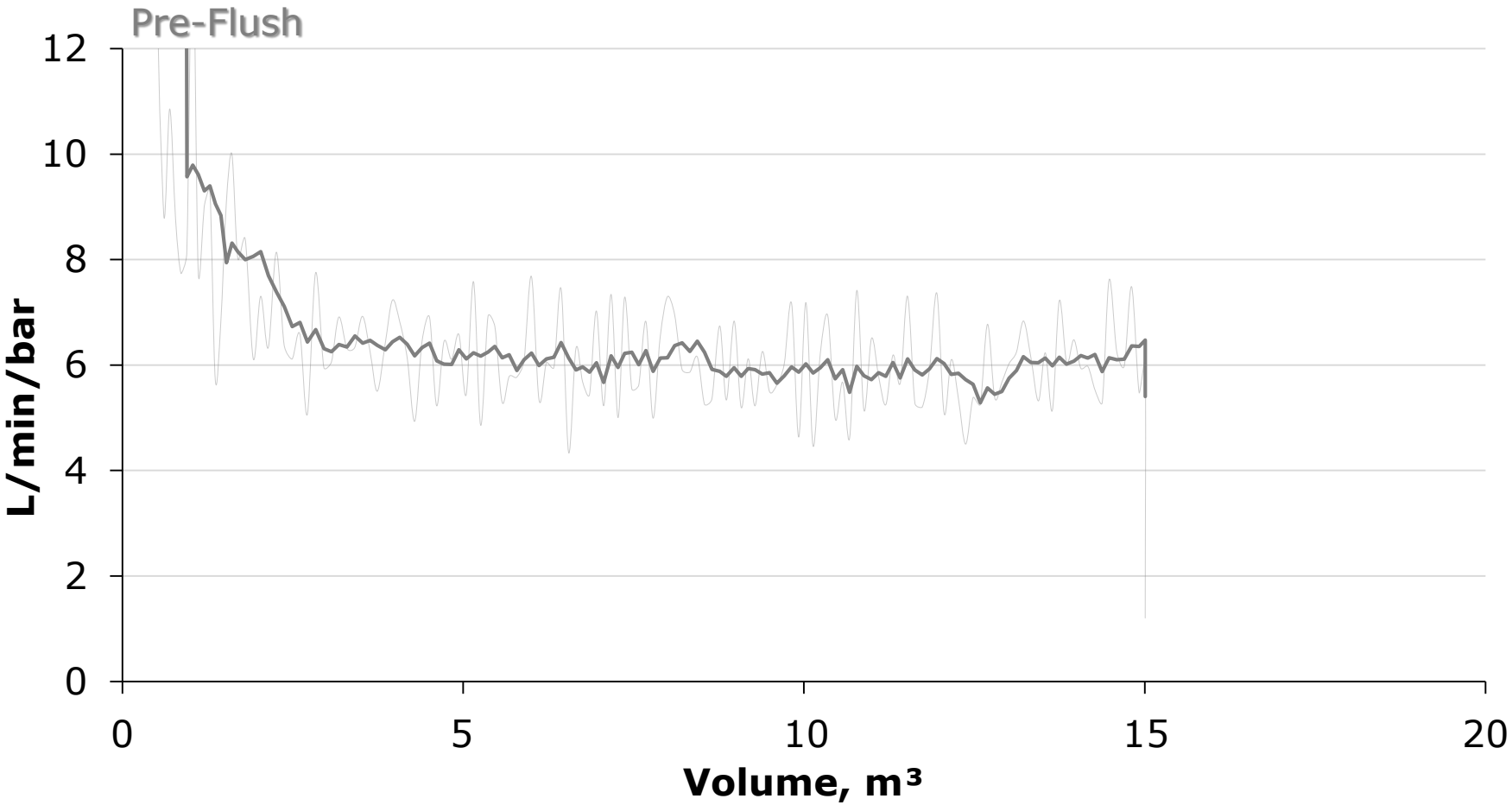


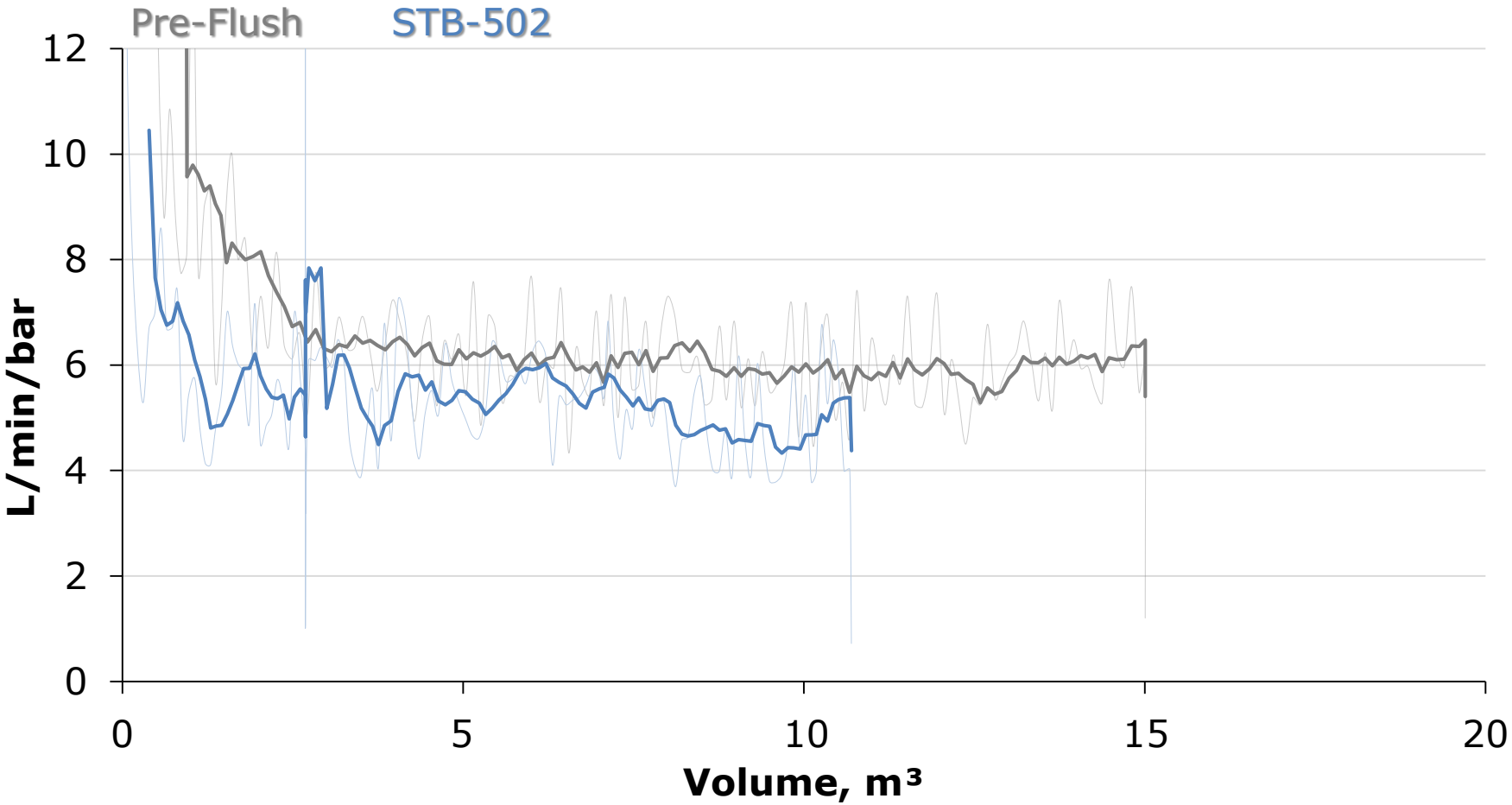
Results for Wash Interval 1



Results for Wash Interval 2



Results for Wash Interval 2



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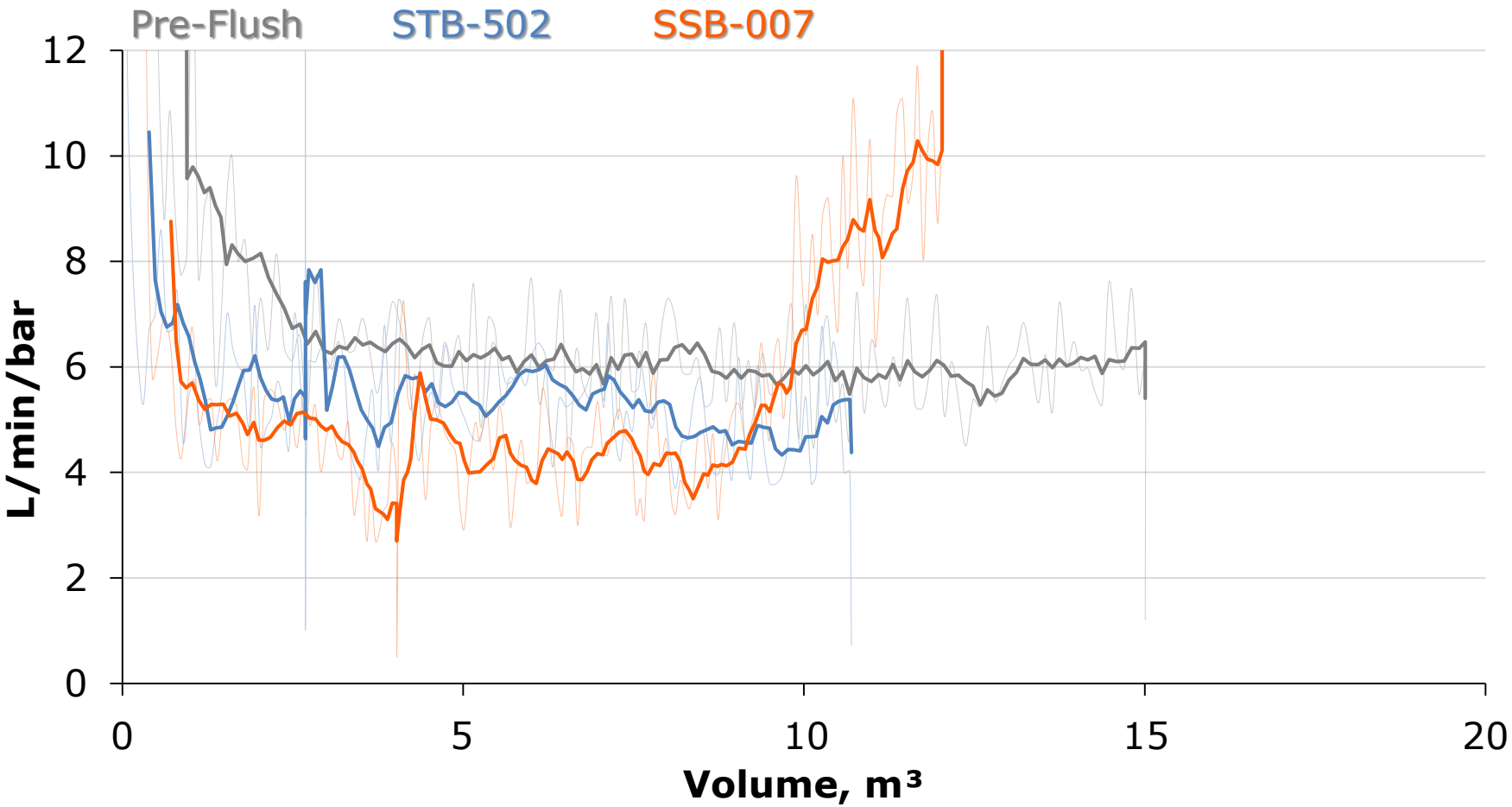
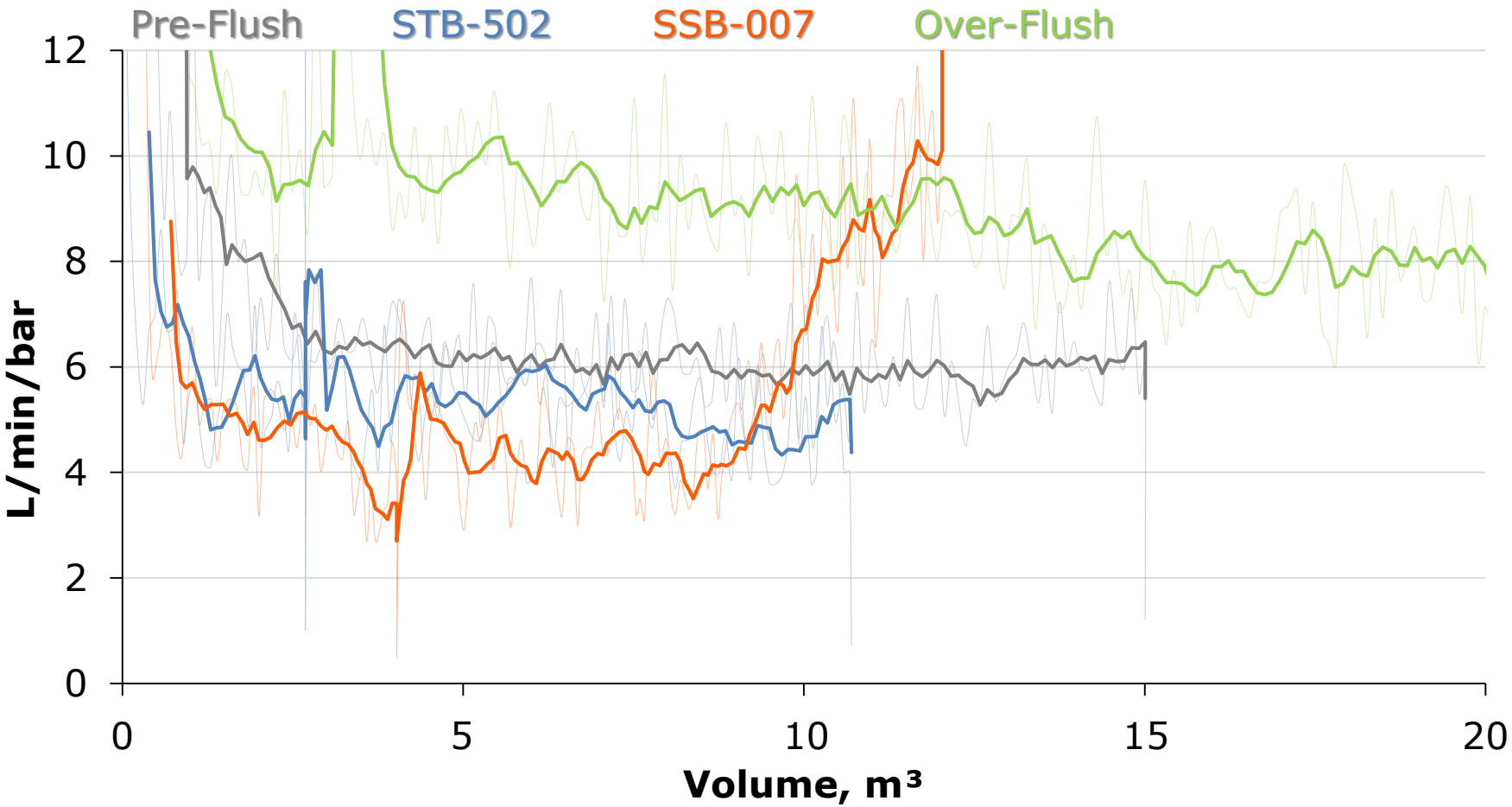
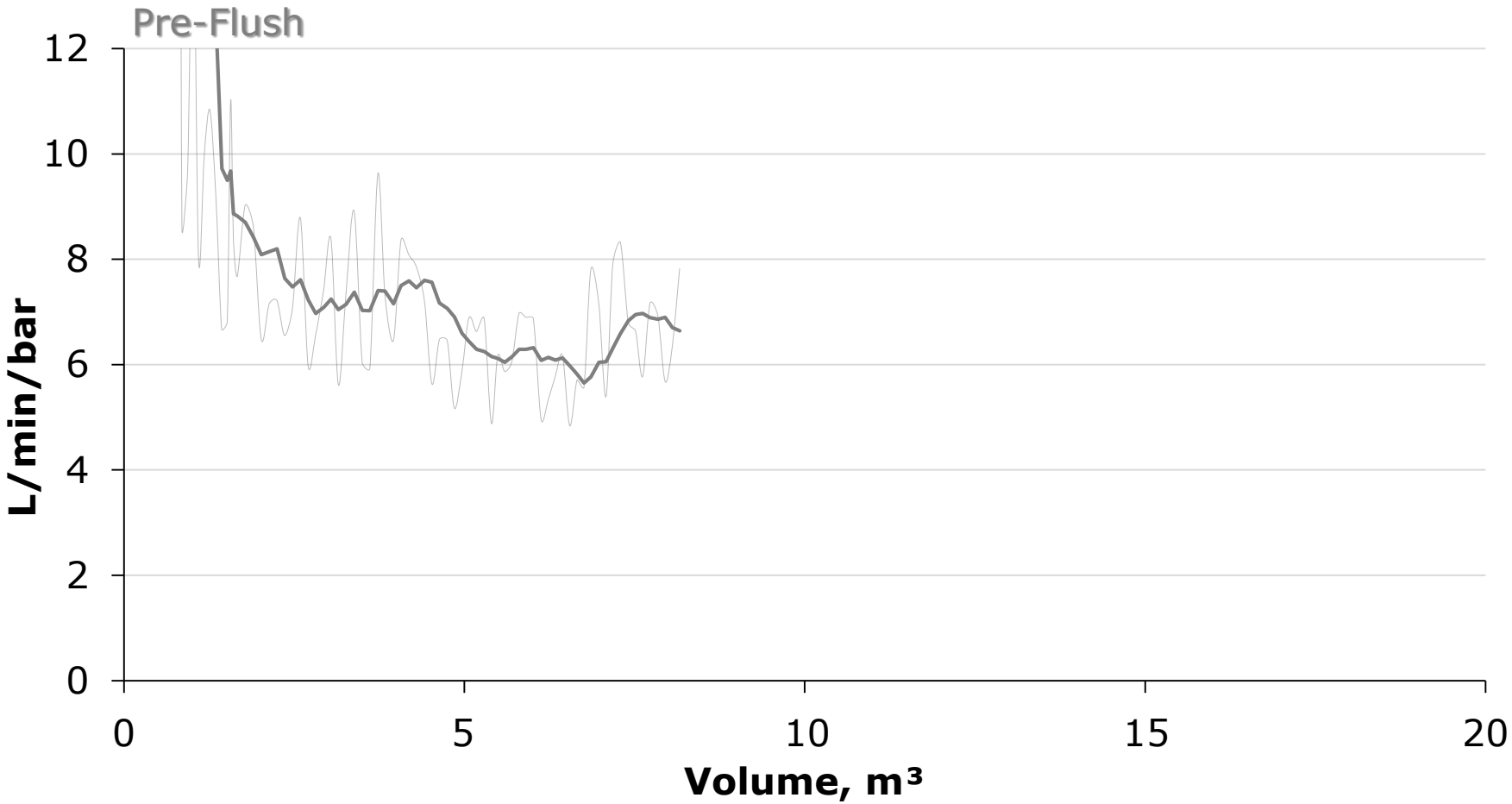


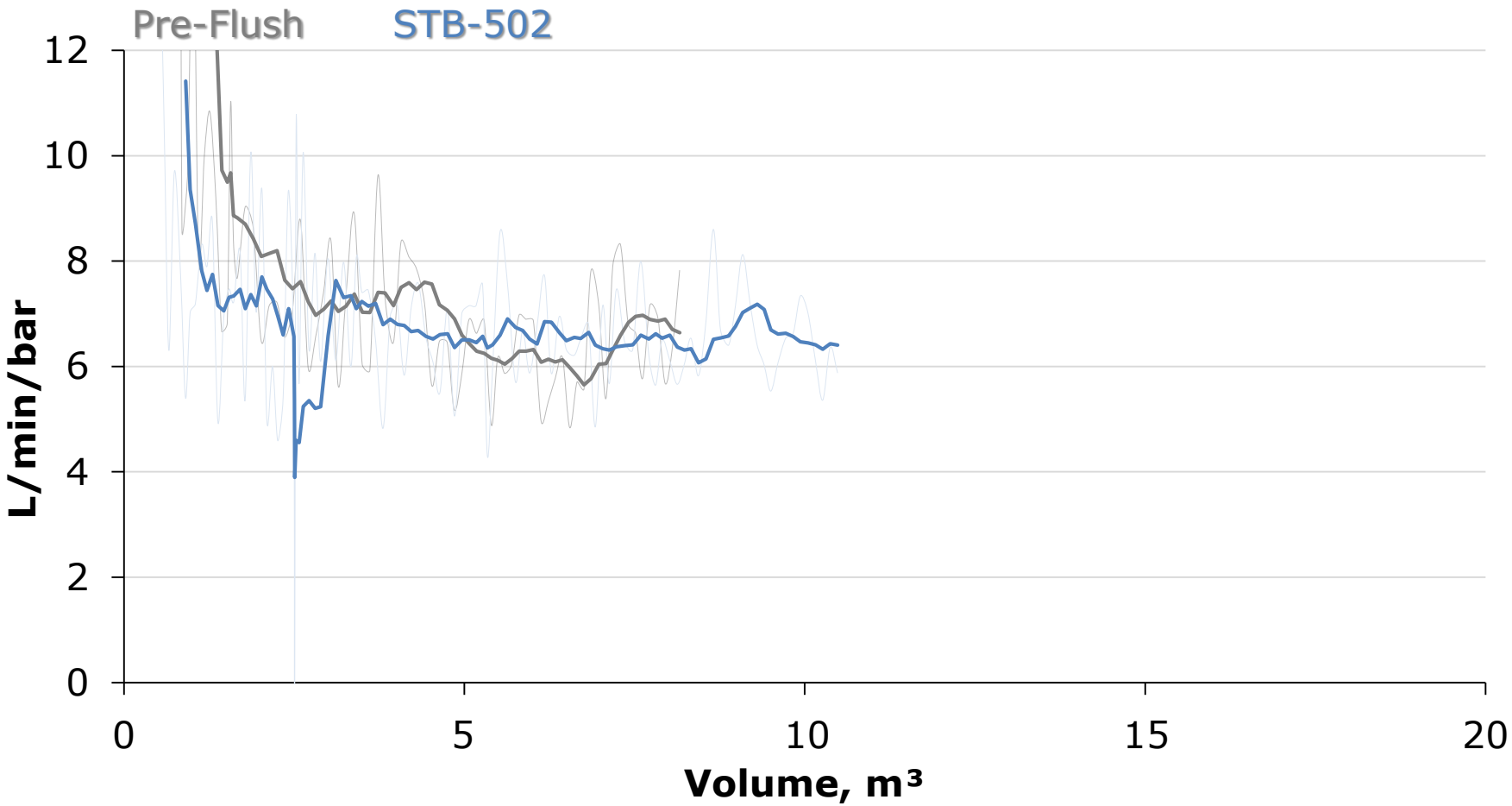
Results for Wash Interval 2



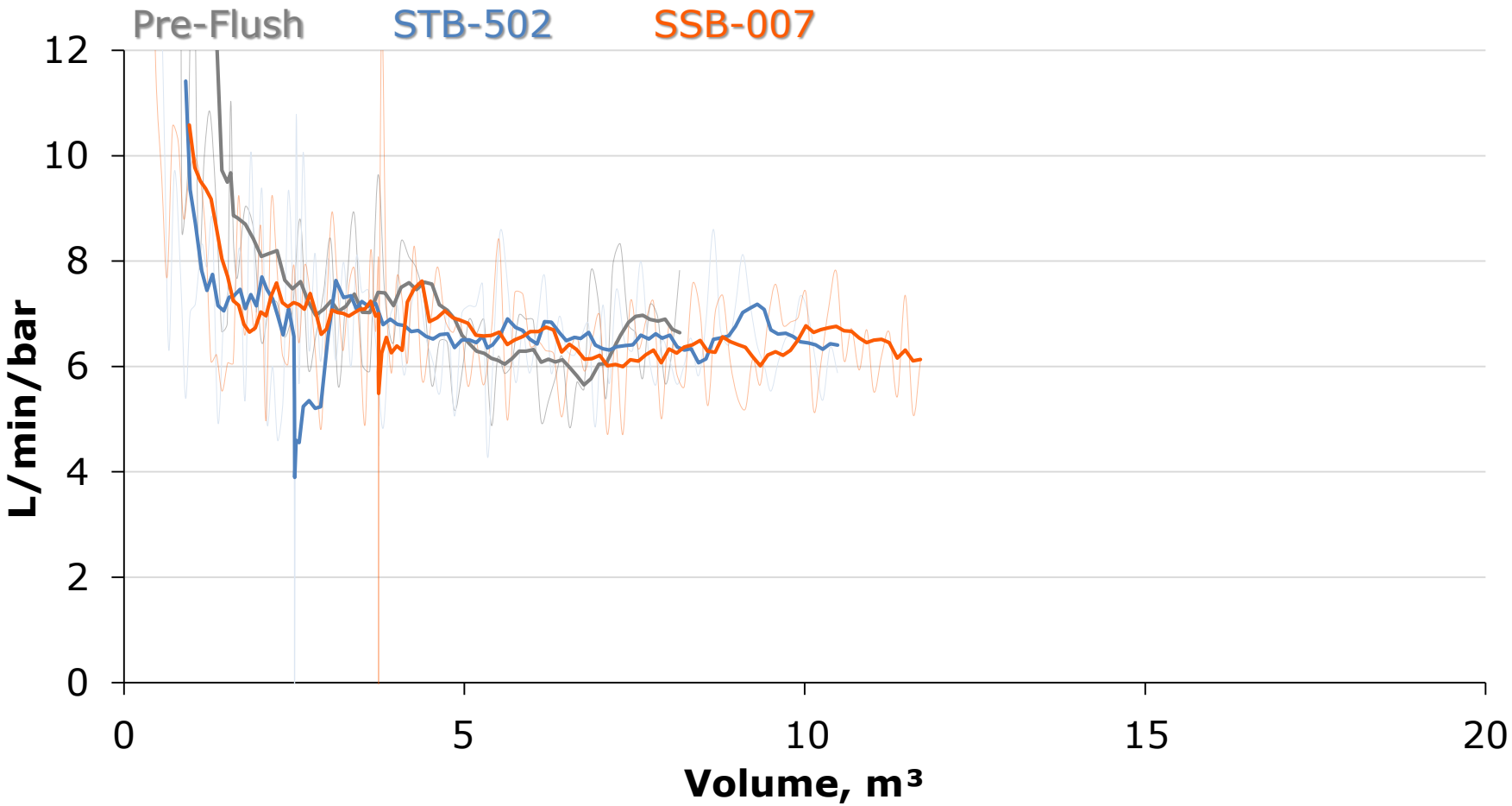
Results for Wash Interval 3



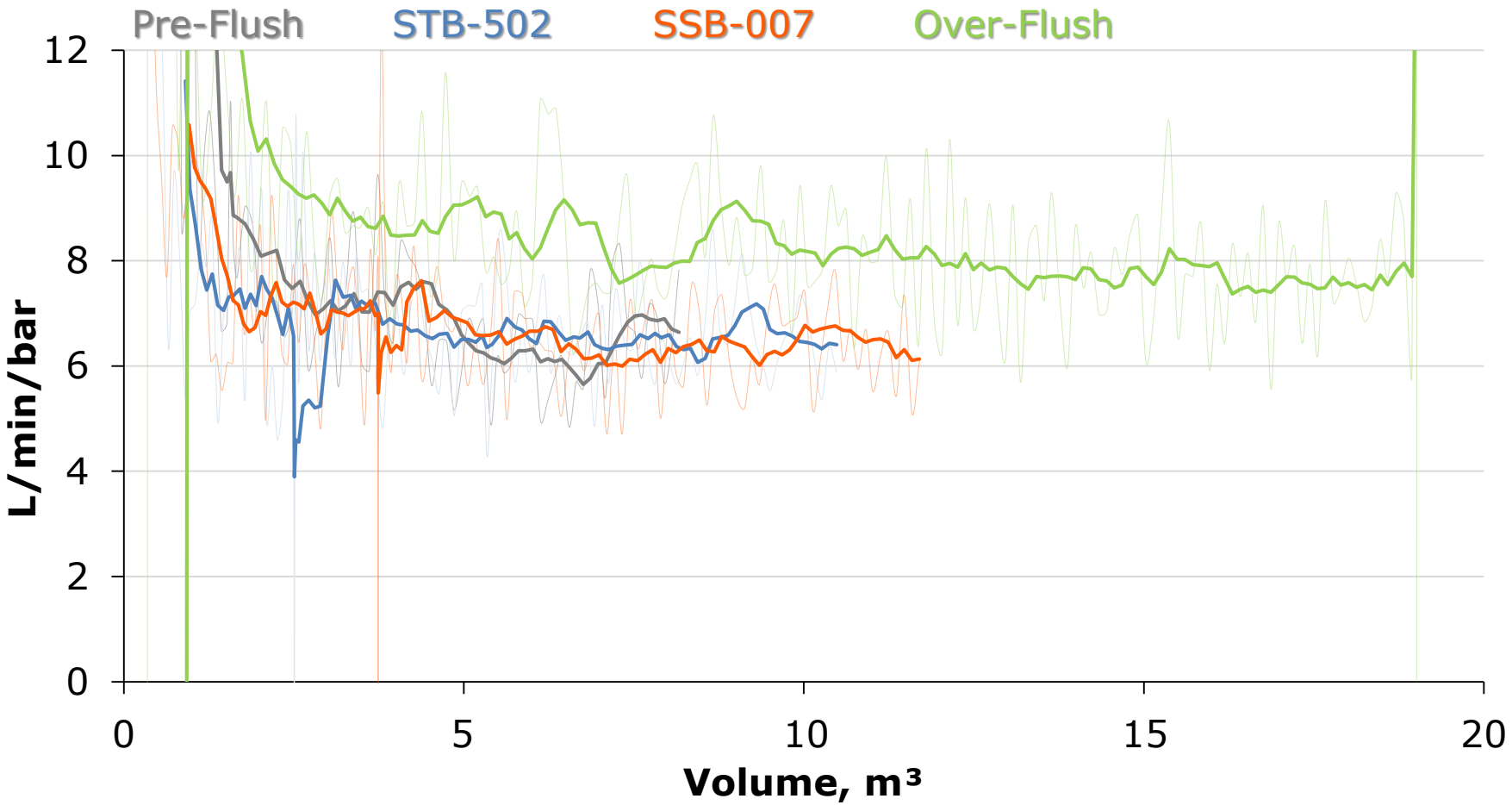
Results for Wash Interval 3



Results for Wash Interval 3

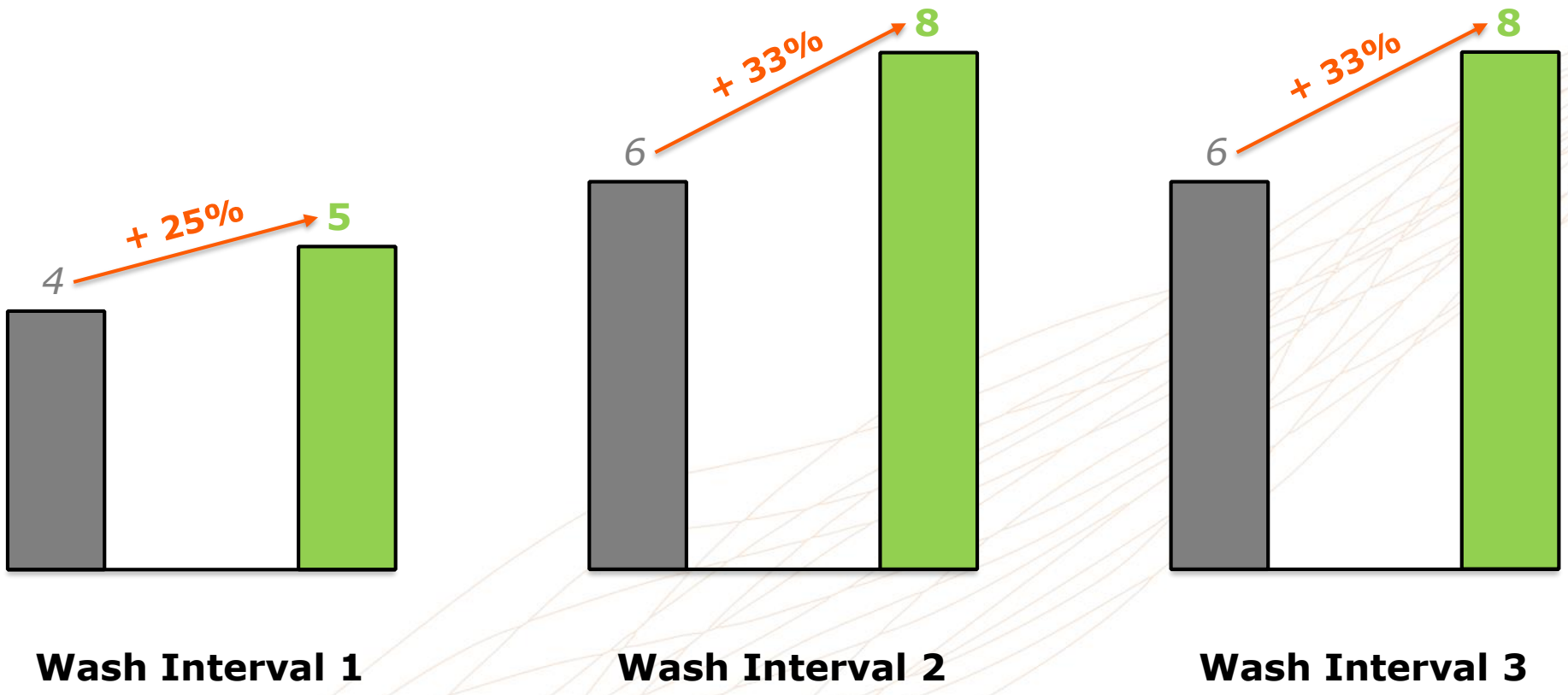


Results for Wash Interval 3



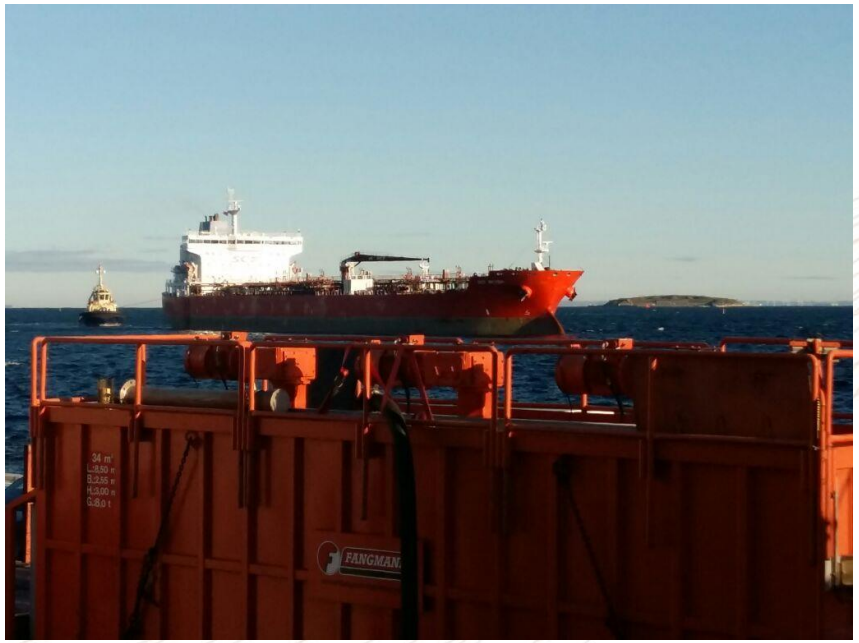
Results for Wash Interval 1-3

Injectivity index (L/min/bar) *before* and **after** fluid treatment



Summary and Q&A

- ✓ Very effective chemical injection via tubing targeting different zones in the perforated liner section
- ✓ Premium fluid diversion and separation employing cup tools
- ✓ Supreme chemical properties of fluid system resulted into a highly improved injectivity of the Bunter sandstone formation



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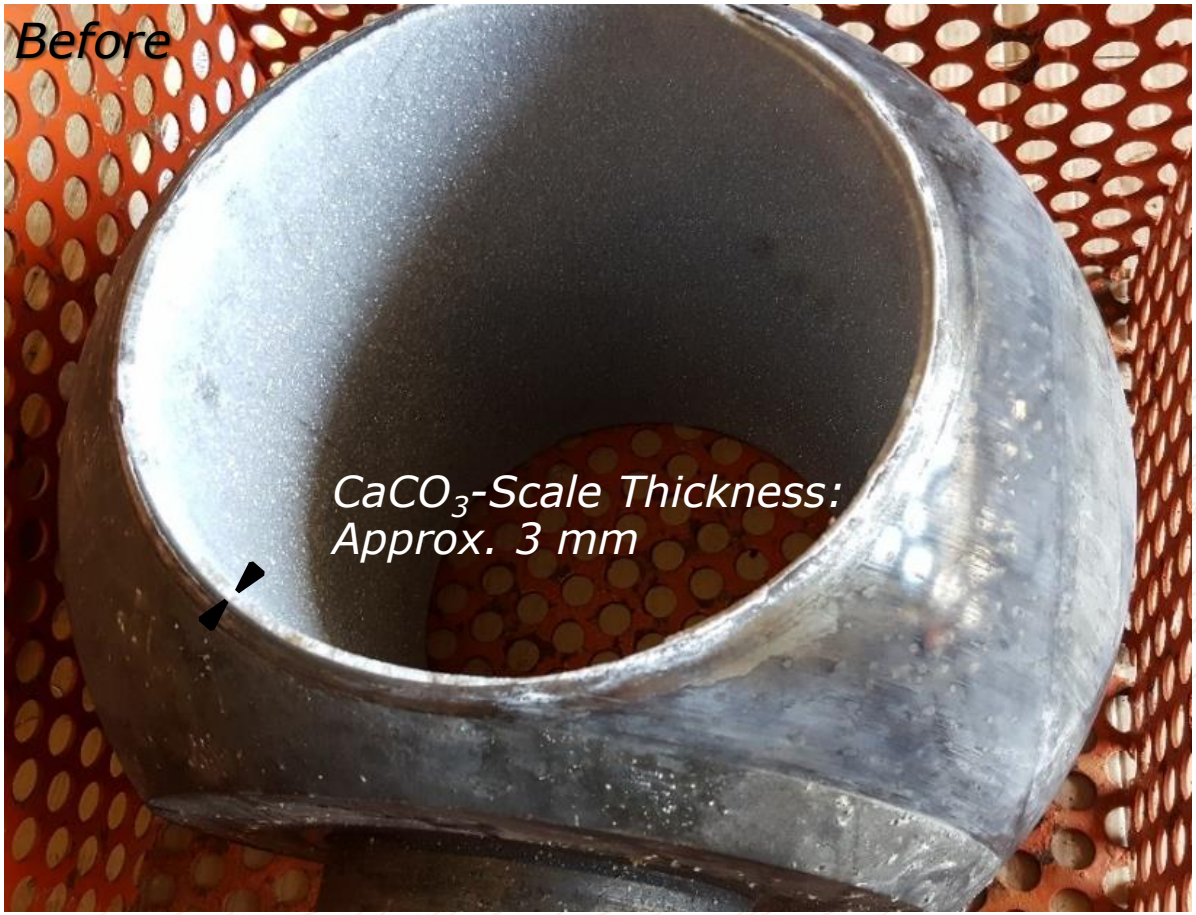
Dr. Nils Recalde Lummer
Senior Chemist

Phone: +49 4471 980 0825
Mobile: +49 151 4142 5882
E-Mail: nlummer@fangmanngroup.com

Tobias Willert
Senior Technical Engineer

Phone: +49 3901 8363 854
Mobile: +49 151 5114 7721
E-Mail: twillert@fangmanngroup.com

Premium Descaling



Premium Descaling