Nils Lummer, Ivan Nesterenko, Detlef Kiel; | Fangmann Energy Services GmbH & Co. KG

INNOVATIVES REAKTIVMATERIAL ZUR VERBESSERUNG DER TRAGFÄHIGKEIT VON SPÜLUNGSSYSTEMEN BEI P&A-APPLIKATIONEN

REACTIVE MATERIAL FOR ENHANCING P&A APPLICATIONS: FLUID DEVELOPMENT, YARD TESTING AND FIELD TRIAL

During P&A applications, cement slurries are commonly pumped on top of water-based mud systems containing high concentrations of bentonite, NaCl, and barite. The carrying capacity of these high-viscous / high-density fluids is crucial for proper cement plug placement and consequently for the long-term integrity of the abandoned well.

This paper introduces the reactive material SWS-330 for facilitating the required division of mud and cement systems. This innovative product is a colloidal suspension of nano-scale particles. In the presence of divalent cations (e.g., $Ca2+$ resulting from cement hydration), the viscosity of this WGK-1 additive suddenly peaks, creating an excellent base for proper cement plug placement.

During yard testing, we filled two different water-based mud systems with a density of 1.29, and 1.45 kg/L, respectively in plexiglass cylinders (height: 200 cm; diameter: 17 cm). For placing an API Class G cement slurry on top of these fluids, we employed standard pumping equipment, as well as a diverter equipped with centralizers. In this context, the reactive fluid SWS-330 greatly

improved the carrying capacity of the mud systems resulting in an optimized cement plug placement. However, extending contact and reaction time by increasing the viscosity and by reducing the density of SWS-330 was deemed recommendable, especially at lower mud densities. Preparing the first application, we determined mutual compatibility and rheology profile of all fluids employing actual field samples. Additionally, we recreated the planned pumping schedule in the lab. Based on these results, we judged the thorough separation of SWS-330 from the cement slurry essential during mixing and pumping procedures.

The aim of the actual application in a German gas well was placing a cement plug from 1.700 to 1.600 TVD on top of a mud system with a density of 1.20 kg/L. For fluid partitioning while pumping, we employed a viscosified fresh-water spacer before and after the SWS-330 step. Additionally, a 1:1 mixture between SWS-330 and the spacer was prepared in a separate tank providing a higher viscosity and lower density of the reactive material. Before mixing and pumping the cement slurry (API Class G at 1.90 kg/L), all pumps and tanks were thoroughly cleaned, as well as purged.

The cement plug was placed exactly as predicted, because of the excellent collaboration between our experienced field and lab personnel combined with the great performance of our innovative product. Lab and field results impressively show that using the reactive fluid SWS-330 can lower material consumption and therefore the cost of mud preparation, while at the same time improving the carrying capacity of mud / cement systems resulting in enhanced P&A applications.

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Competence | Flexibility | Reliability

Enhancing P&A-Applications: Innovative Reactive Material for Improved Carrying Capacity of Mud / Cement Systems

Dr. Nils Lummer

BHT; Freiberg, June 06

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Agenda

Introduction

Yard Testing

Preparation of Field Trial

Field Trial

Summary

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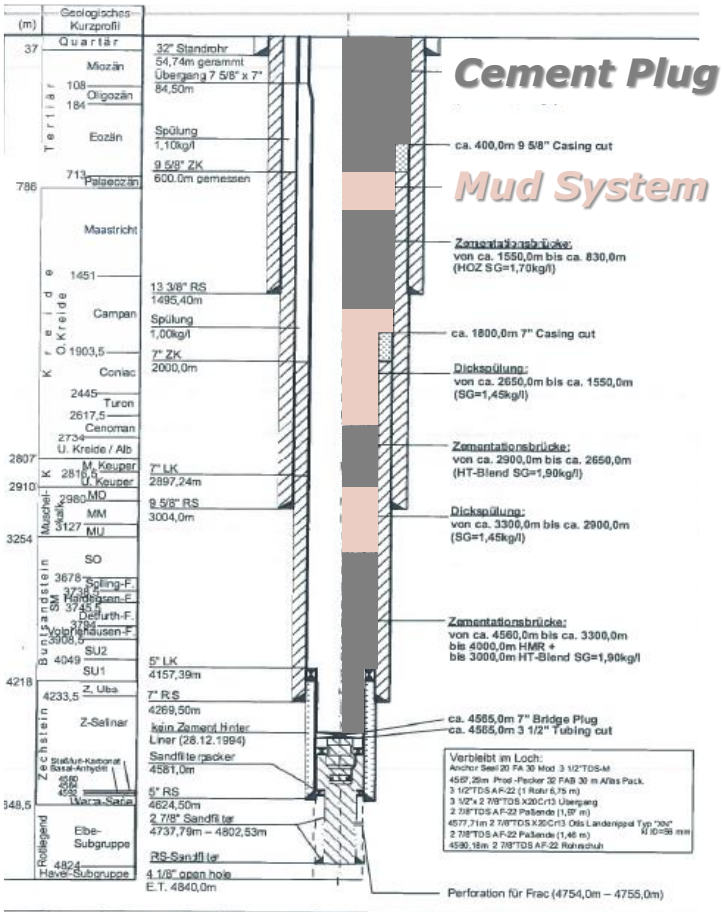
Introduction

P&A-Applications



Target of this project:

Improving carrying capacity of mud systems

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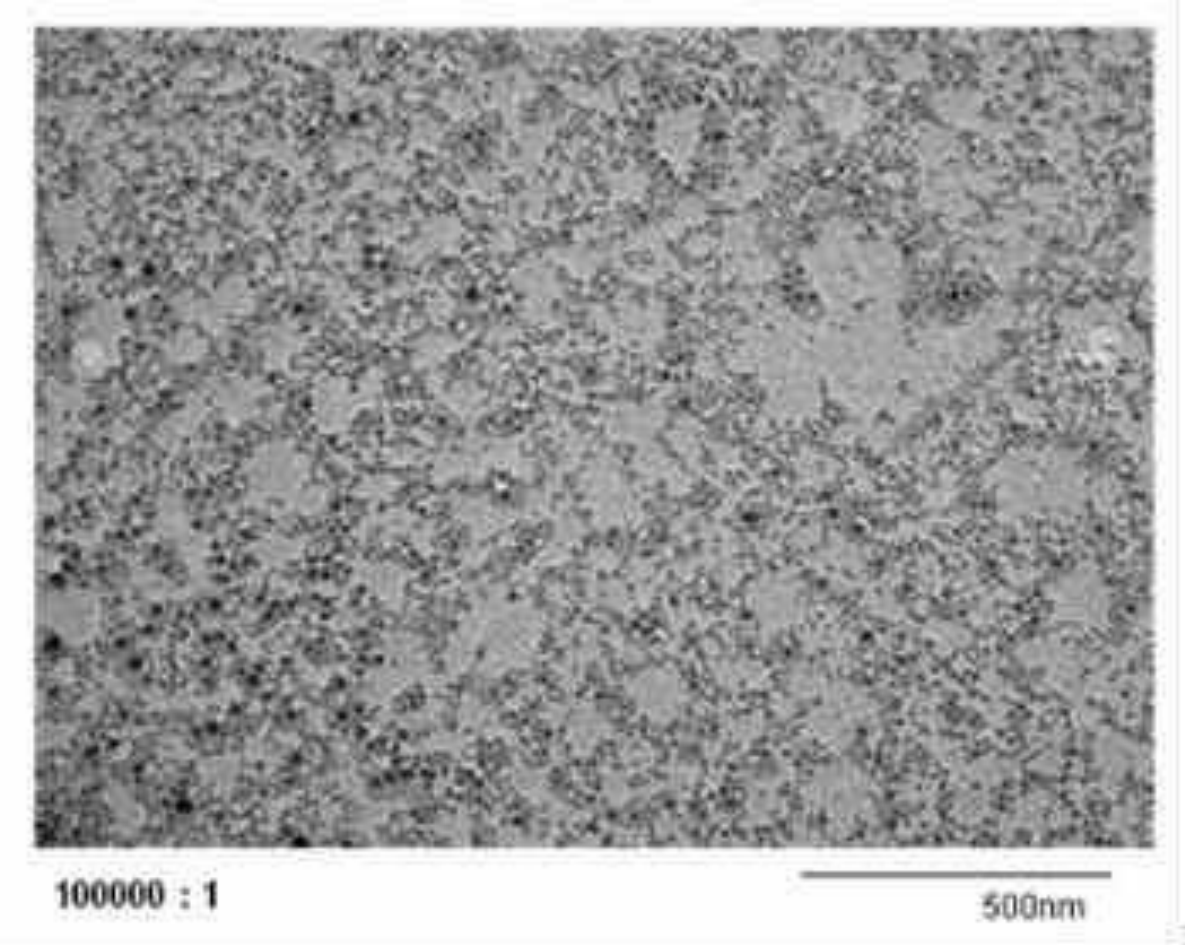
Introduction

SWS-330: Colloidal suspension of nano-scaled non-organic particles



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Agenda

Introduction

Yard Testing

Preparation of Field Trial

Field Trial

Summary

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Yard Testing

Equipment: Twin pump unit, bulk truck and 5 m³ mixing tank

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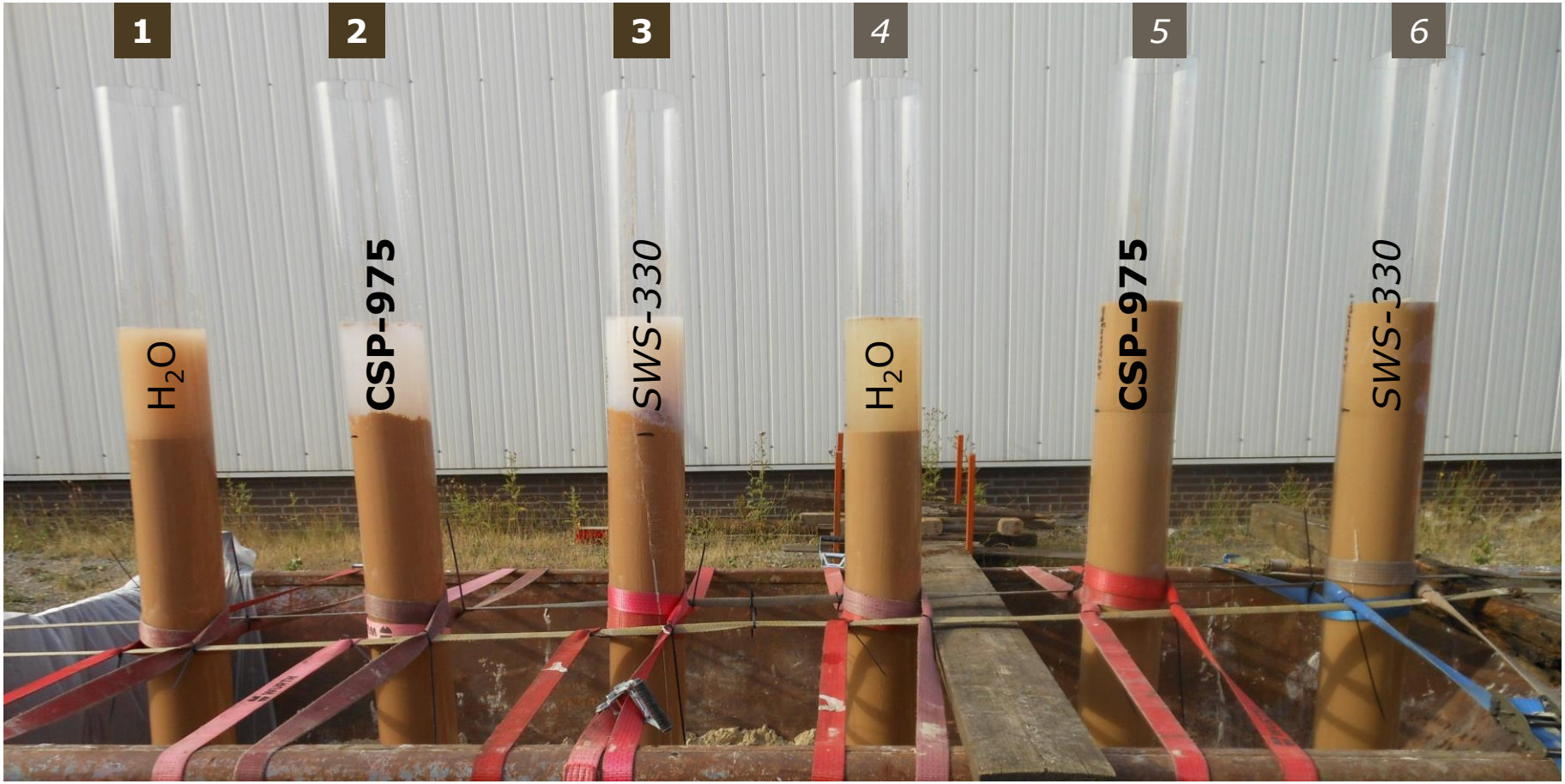
Yard Testing

#1-3: Mud system 1 @ 1.45 kg/L; *#4-6: Mud system 2 @ 1.29 kg/L*



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Yard Testing

#1-3: Mud system 1 @ 1.45 kg/L; *#4-6: Mud system 2 @ 1.29 kg/L*

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Yard Testing

Evaluation after 4 weeks

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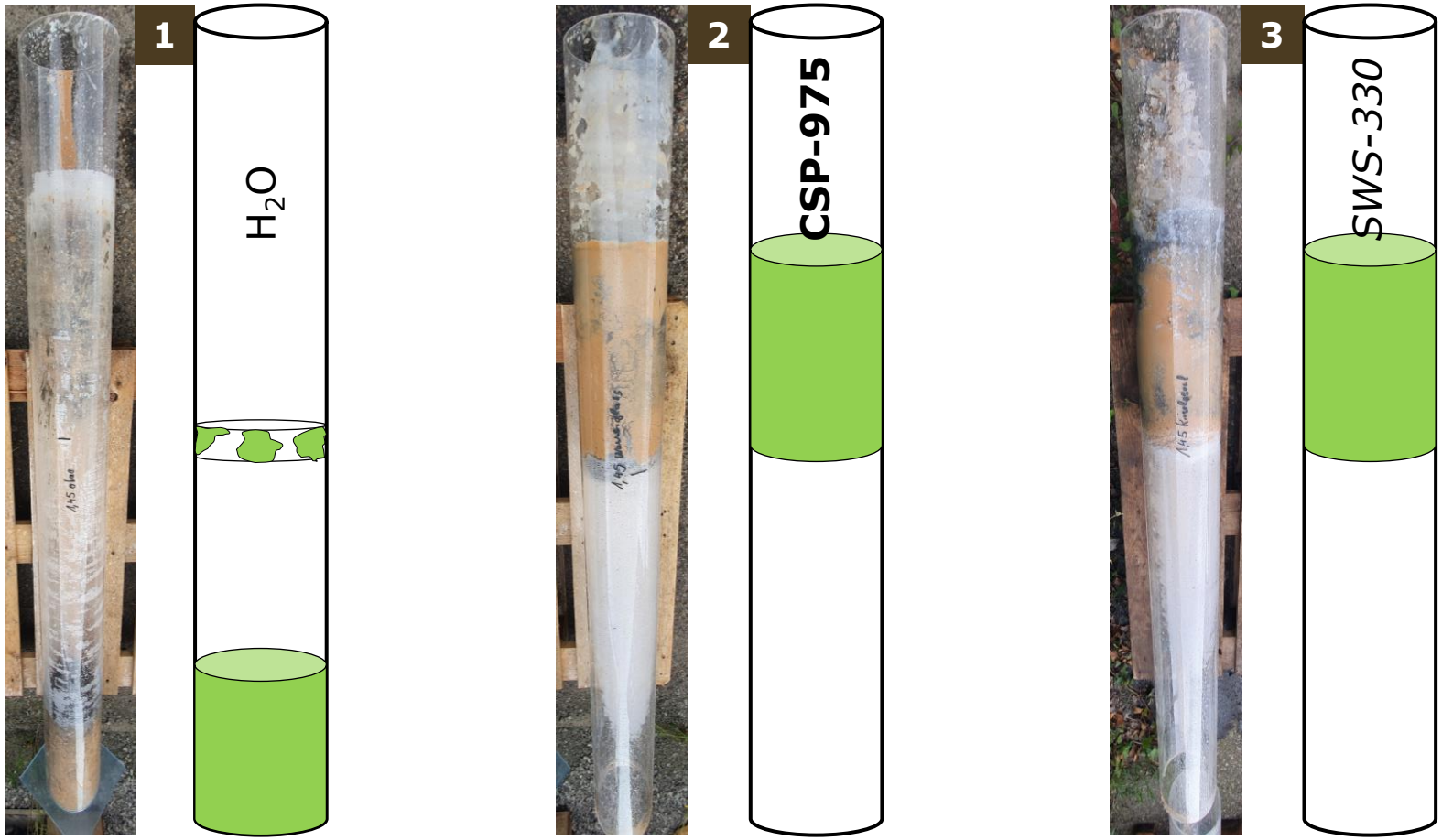
Yard Testing

#1-3: Mud system 1 @ 1.45 kg/L



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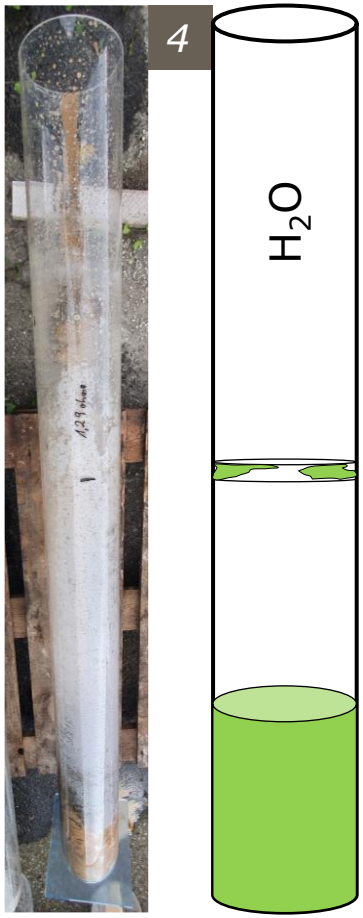
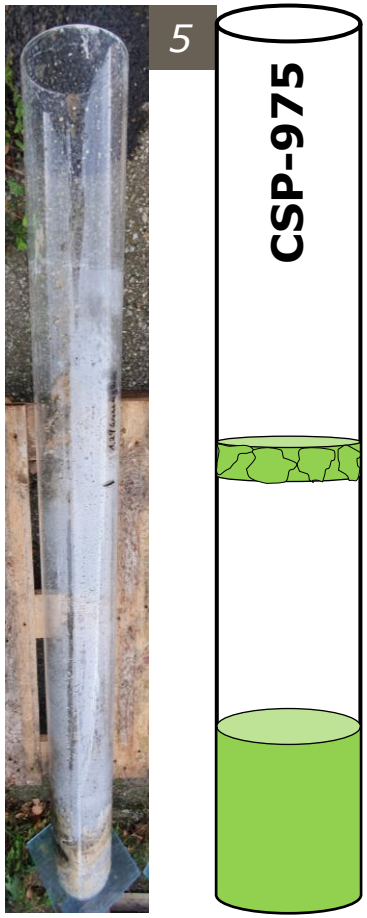
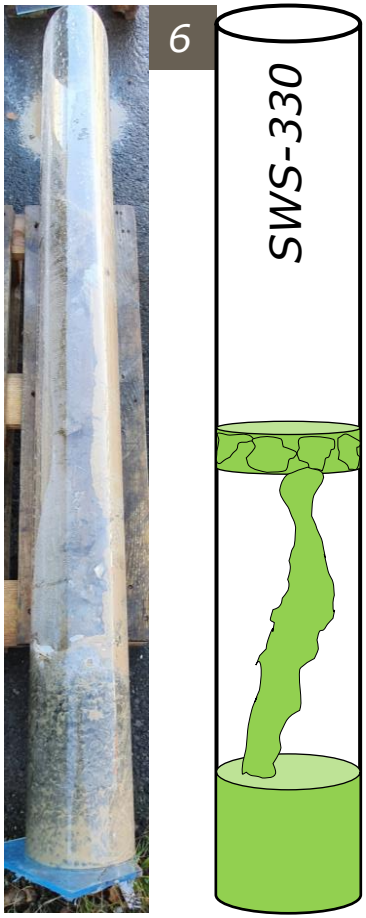
Yard Testing

#4-6: Mud system 2 @ 1.29 kg/L







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Yard Testing

Conclusion

- ✓ The reactive material SWS-330 greatly improves the carrying capacity of the mud / cement system, even at lower mud densities

- ✓ For more effective reactions, extend contact time by increasing the viscosity of SWS-330 and reducing its density

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Agenda

Introduction

Yard Testing

Preparation of Field Trial

Field Trial

Summary

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Preparation of Field Trial

Composition of Fluid Systems

Fluid	Name	Composition	Density, kg/L
1	Pre-Spacer	Fresh-Water + 6 kg/m³ SGL-312	1.00
2	SWS-330	1:1 Mixture with Spacer System	1.18
3	Post-Spacer	Fresh-Water + 6 kg/m³ SGL-312	1.00
4	Mud	Field Sample, as received by client	1.15
5	Cement Slurry	API Class G + 2kg CRE-120	1.90

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Preparation of Field Trial

Compatibility of Fluid Systems

Compatible	Fluid I	Fluid II
1: Yes	Spacer	SWS-330
2: Yes	Cement Slurry	Mud
3: Yes	Spacer	Mud
4: No	Cement Slurry	SWS-330
5: No	Cement Slurry	Spacer
6: No	SWS-330	Mud

Thoroughly cleaning and flushing of equipment is essential

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Agenda

Introduction

Yard Testing

Preparation of Field Trial

Field Trial

Summary

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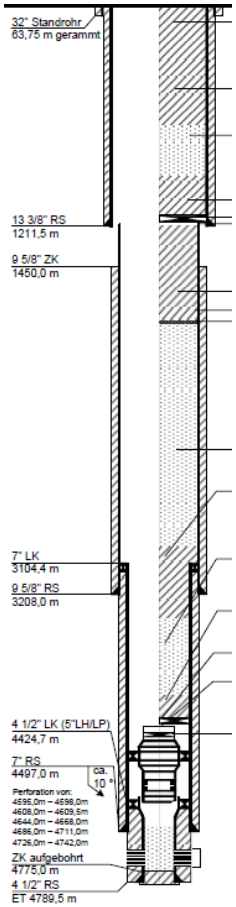
Field Trial

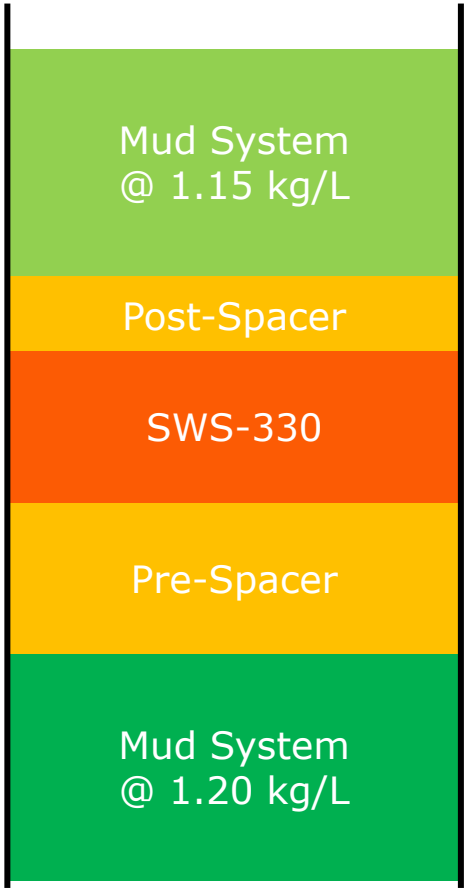
Planned P&A-Procedure



3. Cement Plug: 1,700 – 1,600 m

SWS-330 Step: 1,750 – 1,700 m

2. Mud System: 3,000 – 1,750 m



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Field Trial

Pumping Schedule I

Fluid	Name	Composition	Volume, m³	Density, kg/L	Rate, L/min
1	Pre-Spacer	Fresh-Water + 6 kg/m³ Xanthan Gum	2	1,00	300
2	SWS-330	1:1 Mixture with Spacer System	2	1,18	300
3	Post-Spacer	Fresh-Water + 6 kg/m³ Xanthan Gum	1	1,00	300
4	Mud	As received by client	4	1,15	300

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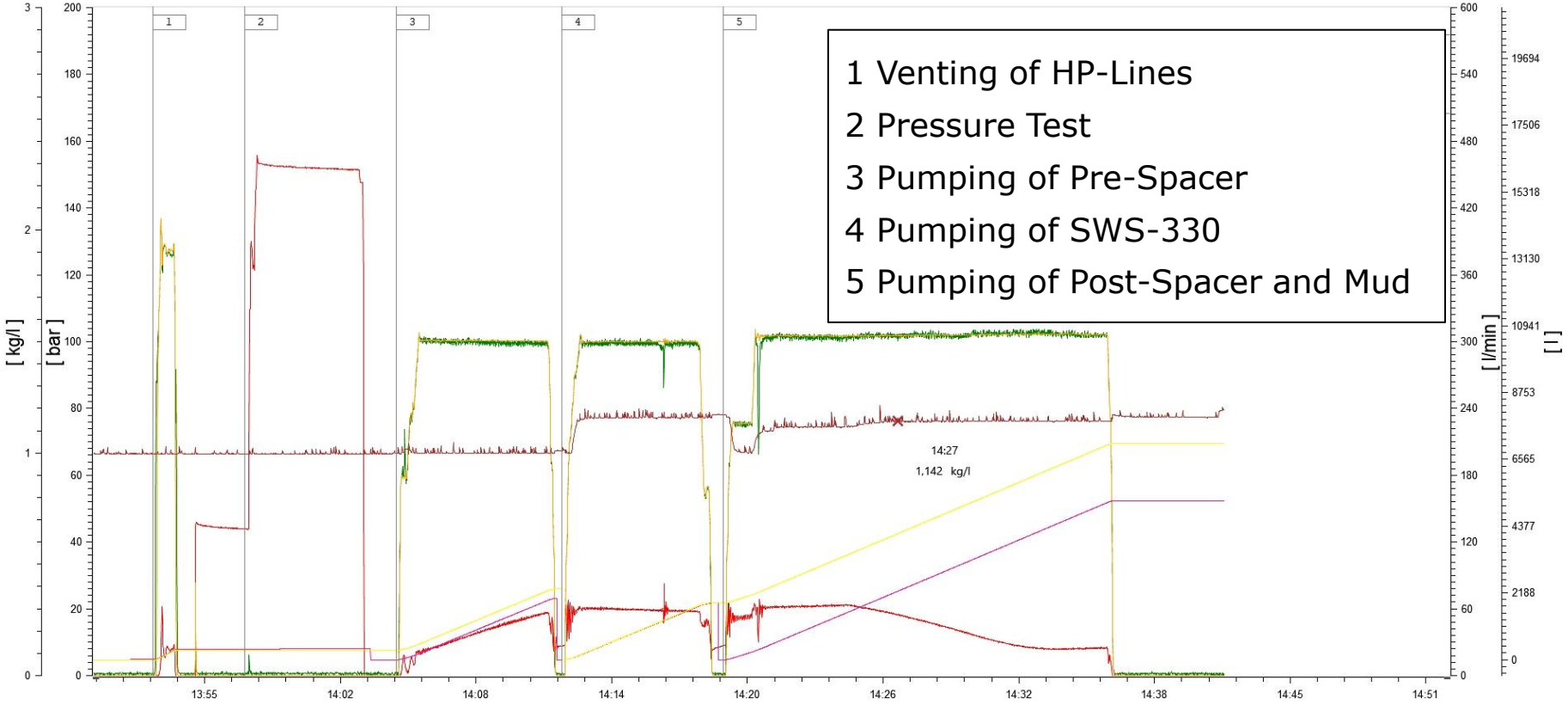
Field Trial

Pumping Schedule I

Density, kg/L | Pressure, bar | Rate, L/min | Volume, L



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Field Trial

Pumping Schedule II

Fluid	Name	Composition	Volume, m³	Density, kg/L	Rate, L/min
1	Spacer	Fresh-Water	2	1,00	300
2	Cement Slurry	API Class G + 2kg CRE-120	4	1,90	300
3	Mud	As received by client	5	1,15	600

Fluid separation, as well as thoroughly cleaning and flushing of equipment is essential

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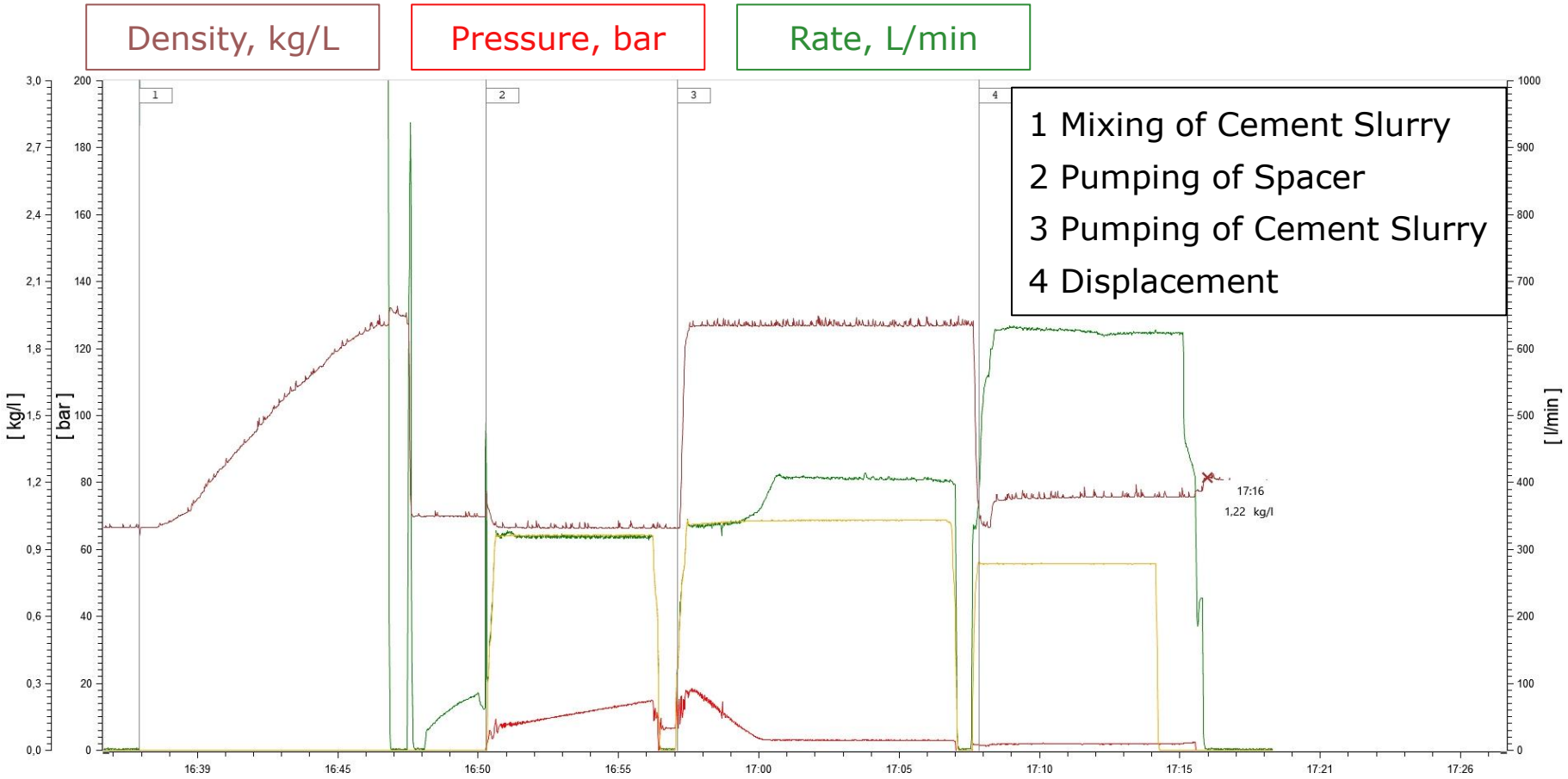
Field Trial

Pumping Schedule II



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Field Trial

Equipment on Site

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Field Trial

Conclusion

- ✓ SWS-330 is a WGK-1 classified product with high temperature tolerance
- ✓ SWS-330 is readily mixable and pumpable with standard equipment
- ✓ Separation between reactive material and cement slurry is essential
- ✓ No additional PPE is required while handling this reactive material
- ✓ Thoroughly cleaning and flushing of equipment is mandatory
- ✓ Smooth operation with experienced FES-team
- ✓ Placement of cement plug exactly as planned

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Agenda

Introduction

Yard Testing

Preparation of Field Trial

Field Trial

Summary

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Summary

- ✓ **FES: Reliable partner for innovative solutions and long-term projects**
- ✓ **Excellent collaboration of experienced operational team with the FES-lab**
- ✓ **Improved carrying capacity of mud / cement systems employing a WGK-1 product**
- ✓ **Enhanced fluid separation, even at low mud densities resulting in material and cost saving potential**

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Ready for Service

For clarification, please contact me directly

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