Chemical Sand Consolidation Experiences in Austrian Gas Fields

Workshop

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Goal: highlight brown-field operation opportunities

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INTERNAL BLOG

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How to produce 6.5 million Nm3 natural gas in six months from a plug and abandon candidate well?

The Subsurface Engineering Team in OMV Austria and the Well Optimization & Integrity Team continuously work together to optimize and improve the national oil and gas production in Austria. This was also the case with the Rabensburg West 4 gas well, a plug and abandon candidate due to sand production and shut-in for years waiting for a workover rig to arrive to execute the abandonment. The vertical well has 2 meter perforations at a depth of 1061,5-1063,5 mMD (16. Sarmat reservoir). But because of friable sand influx with the production the tubing was filled up to 880 m depth with sand.

Eliminating sand production at the sand face was the only valuable option to continue hydrocarbon production. The target of the project was to research and apply a solution, which is technically sound, readily available in Europe, with reduced HSSE risks and little economic impact. To control intervention costs, it was decided to favor sand control solutions for rig less interventions. Collaboratively, the teams evaluated formation rock consolidation with the help of an internally catalyzed aqueous-based emulsion of curable epoxy resin (ICABECER). Laboratory testing proved the system's suitability for the target well and confirmed the viability of the planned operations schedule to deploy the treatment via coiled tubing. In addition, the testing also eliminated concerns about permeability reduction because of the coating of sand grains with the consolidating resin.

The consolidation work started with the removal of the sand from the tubing and the casing. Foam was used to lift the significant amount of sand from the wellbore.

Agenda

- Introduction
- Intervention Selection
- Candidate Selection
- Treatment Design
- Treatment Placement
- Results
- Conclusions
- Potential Future Use of Technology

Introduction

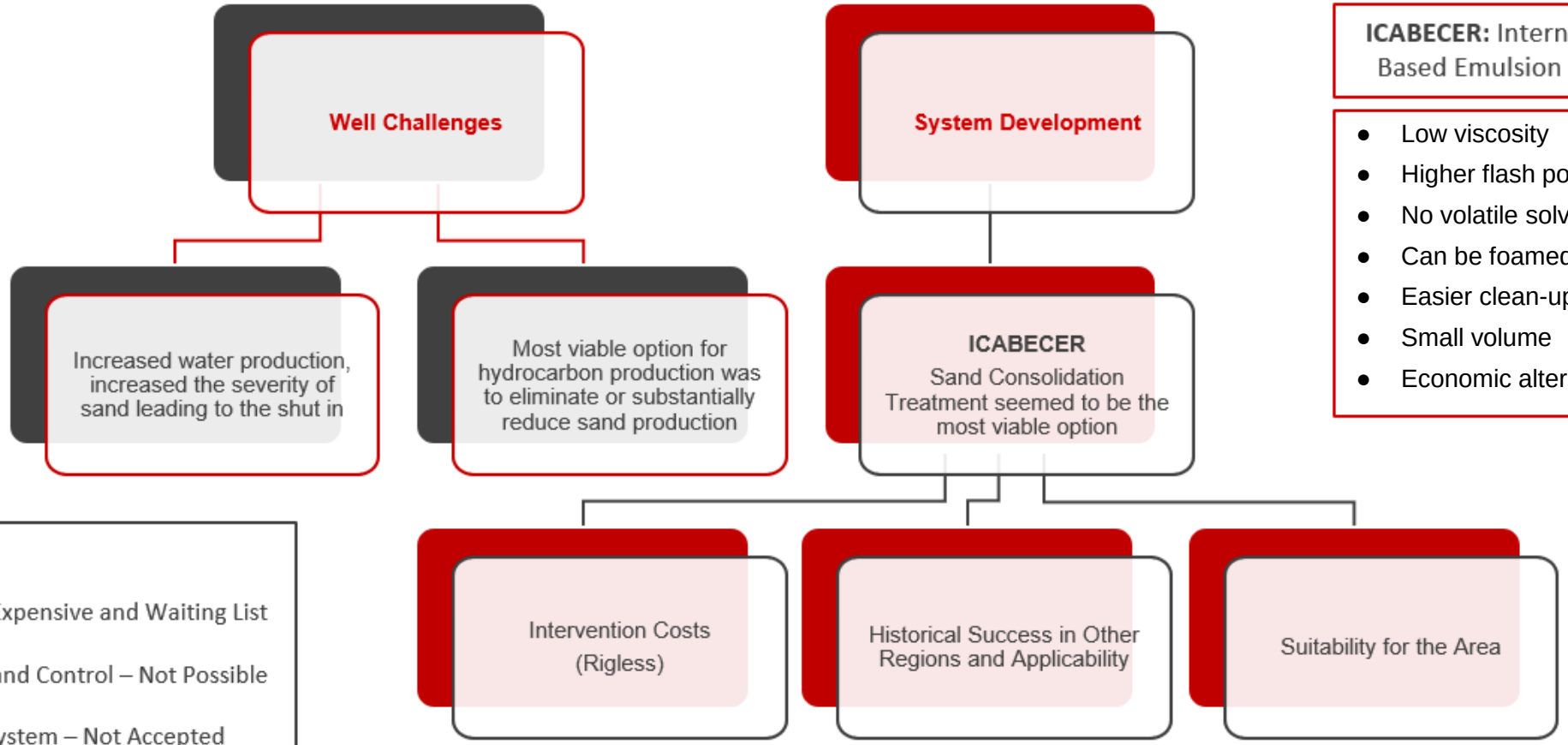
- **Sand Production**
  - One of the major challenges due to unconsolidated formation or mechanical failure
  - Several consequences (erosion, affecting productivity, increase production cost…)

- **Mature Field**
  - Water Production
  - Remaining hydrocarbons
  - Budgetary constraints

- **Traditional Methods**
  - Passive sand control (selective perforation, drawdown management...)
  - Active sand control (stand alone screens, gravel packs…)

- **Formation Sand Consolidation**
  - Resin consolidation since 1940`s
  - Develop strength with minimal permeability loss

Intervention Selection



ICABECER: Internally Catalyzed Aqueous-Based Emulsion of Curable Epoxy Resin

- Low viscosity
- Higher flash point (safer)
- No volatile solvents
- Can be foamed (N2)
- Easier clean-up
- Small volume
- Economic alternative

Other Options:

- Work Over – Expensive and Waiting List
- Mechanical Sand Control – Not Possible
- Resin Based System – Not Accepted

Candidate Selection

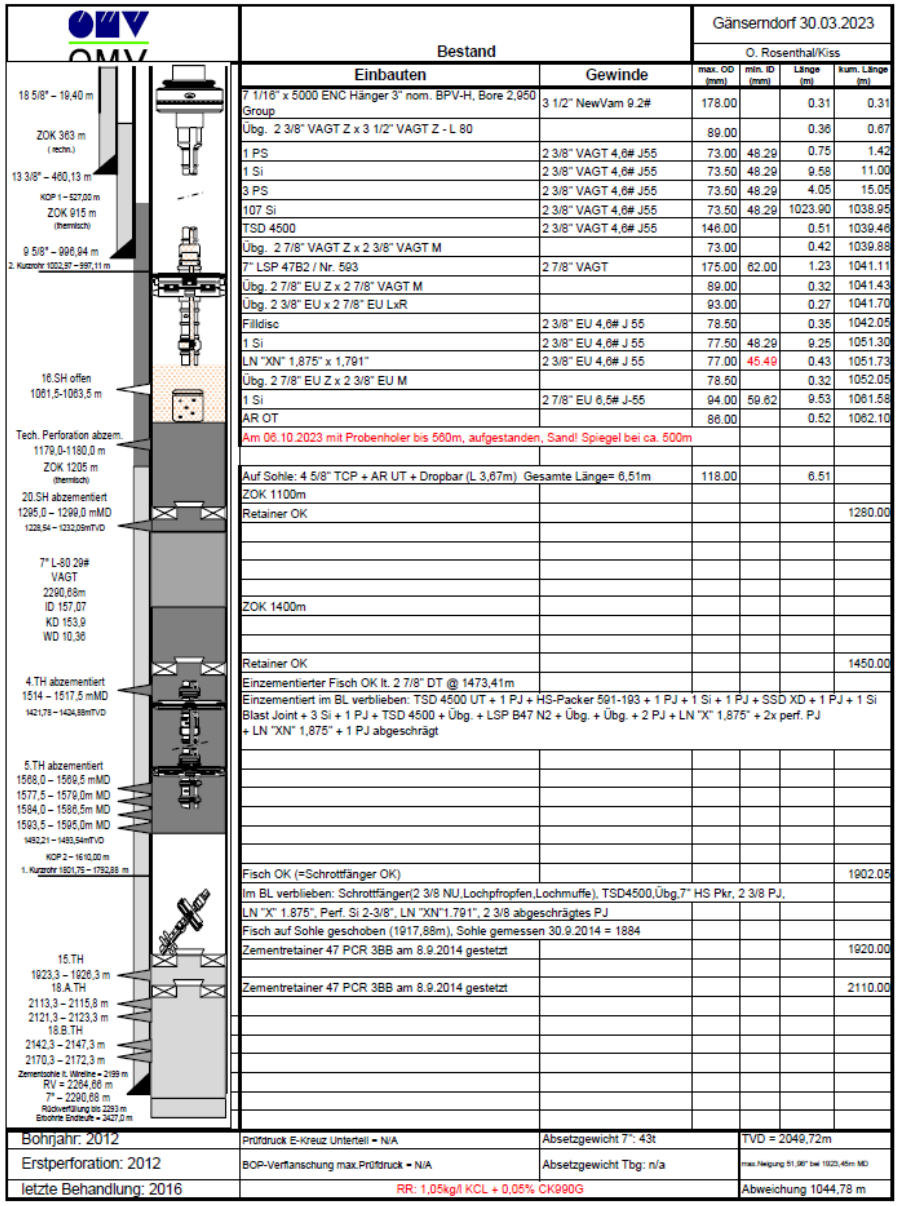
- **ICABECER* Design**
  - Up to 105 °C
  - 3 m for conventional resins – 30 m for ICABECER
  - Recommended >500 mD, tested down to 100 mD
  - Works in non-well-sorted sand and heterogeneous sand but easier to place in homogeneous
  - Economical compared to other sand control techniques (through tubing)
  - Liquid or gas producer

*Internally Catalyzed Aqueous-Based Emulsion of Curable Epoxy Resin

- **Well / Field Information**
  - 32 °C
  - 2m interval (usually <5 m on this field)
  - 150 mD
  - Homogeneity but poorly sorted sand with 3-21% fines
  - Important focus on economics even though main target was ICABECER validation
  - Gas producer

A well affected by water and solids production, planned for P&A was selected

Candidate Selection



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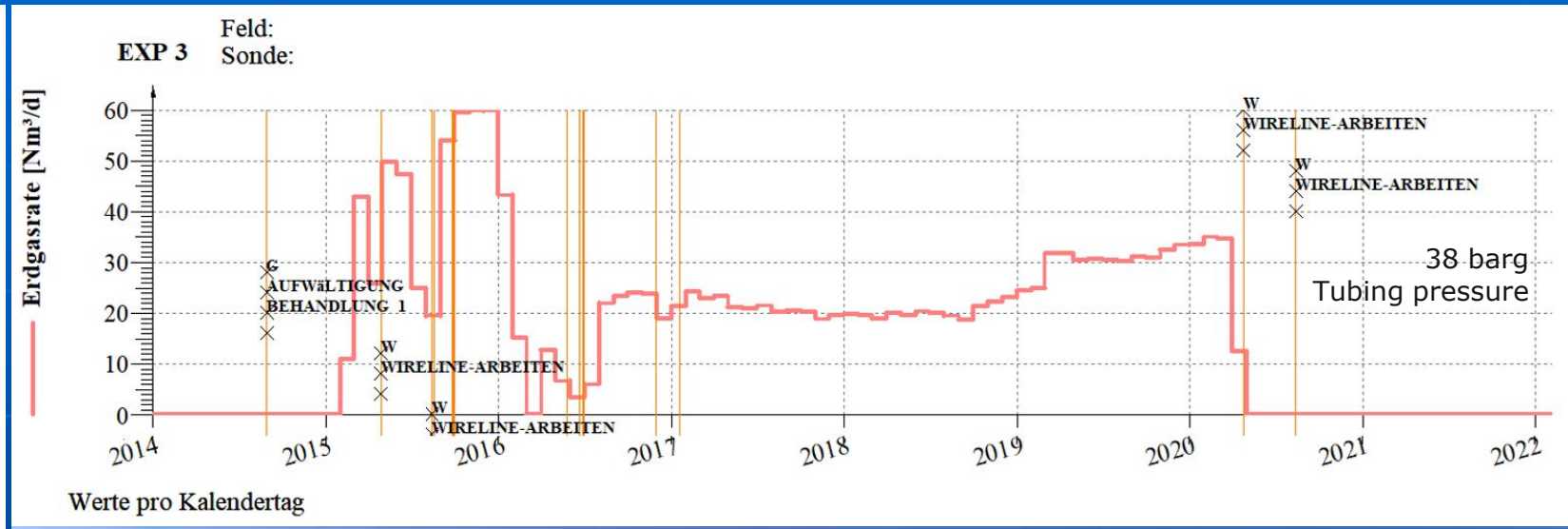
Gänserndorf 30.03.2023

O. Rosenthal/Kiss

Bestand – Einbauten	Gewinde	max. OD (mm)	min. ID (mm)	Länge (m)	kum. Länge (m)
7 1/16" x 5000 ENC Hänger 3" nom. BPV-H, Bore 2,950 Group	3 1/2" NewVam 9.2#	178.00		0.31	0.31
Übg. 2 3/8" VAGT Z x 3 1/2" VAGT Z - L 80		89.00		0.36	0.67
1 PS	2 3/8" VAGT 4,6# J55	73.00	48.29	0.75	1.42
1 Si	2 3/8" VAGT 4,6# J55	73.50	48.29	9.58	11.00
3 PS	2 3/8" VAGT 4,6# J55	73.50	48.29	4.05	15.05
107 Si	2 3/8" VAGT 4,6# J55	73.50	48.29	1023.90	1038.95
TSD 4500	2 3/8" VAGT 4,6# J55	146.00		0.51	1039.46
Übg. 2 7/8" VAGT Z x 2 3/8" VAGT M		73.00		0.42	1039.88
7" LSP 47B2 / Nr. 593	2 7/8" VAGT	175.00	62.00	1.23	1041.11
Übg. 2 7/8" EU Z x 2 7/8" VAGT M		89.00		0.32	1041.43
Übg. 2 3/8" EU x 2 7/8" EU LxR		93.00		0.27	1041.70
Filldisc	2 3/8" EU 4,6# J 55	78.50		0.35	1042.05
1 Si	2 3/8" EU 4,6# J 55	77.50	48.29	9.25	1051.30
LN "XN" 1,875" x 1,791"	2 3/8" EU 4,6# J 55	77.00	45.49	0.43	1051.73
Übg. 2 7/8" EU Z x 2 3/8" EU M		78.50		0.32	1052.05
1 Si	2 7/8" EU 6,5# J-55	94.00	59.62	9.53	1061.58
AR OT		86.00		0.52	1062.10
Am 06.10.2023 mit Probenholer bis 560m, aufgestanden, Sand! Spiegel bei ca. 500m					
Auf Sohle: 4 5/8" TCP + AR UT + Dropbar (L 3,67m) Gesamte Länge= 6,51m		118.00		6.51	
ZOK 1100m					
Retainer OK					1280.00
ZOK 1400m					
Retainer OK					1450.00
Einzementierter Fisch OK lt. 2 7/8" DT @ 1473,41m					
Einzementiert im BL verblieben: TSD 4500 UT + 1 PJ + HS-Packer 591-193 + 1 PJ + 1 Si + 1 PJ + SSD XD + 1 PJ + 1 Si Blast Joint + 3 Si + 1 PJ + TSD 4500 + Übg. + LSP B47 N2 + Übg. + Übg. + 2 PJ + LN "X" 1,875" + 2x perf. PJ + LN "XN" 1,875" + 1 PJ abgeschrägt					
Fisch OK (=Schrottfänger OK)					1902.05
Im BL verblieben: Schrottfänger(2 3/8 NU,Lochpfropfen,Lochmuffe), TSD4500,Übg.7" HS Pkr, 2 3/8 PJ,					
LN "X" 1.875", Perf. Si 2-3/8", LN "XN"1.791", 2 3/8 abgeschrägtes PJ					
Fisch auf Sohle geschoben (1917,88m), Sohle gemessen 30.9.2014 = 1884					
Zementretainer 47 PCR 3BB am 8.9.2014 gestetzt					1920.00
Zementretainer 47 PCR 3BB am 8.9.2014 gestetzt					2110.00

Bohrjahr: 2012	Prüfdruck E-Kreuz Unterteil = N/A	Absetzgewicht 7": 43t	TVD = 2049,72m
Erstperforation: 2012	BOP-Verflanschung max.Prüfdruck = N/A	Absetzgewicht Tbg: n/a	max.Neigung 51,98° bei 1923,45m MD
letzte Behandlung: 2016	RR: 1,05kg/l KCL + 0,05% CK990G		Abweichung 1044,78 m



Treatment Design

- Lab tests to evaluate permeability reduction
- CT for more precise placement

ICABECER design volume: - 1m radial penetration

Bore Hole Diameter (D)	6.184	inches	
Treatment Radial Penetration Depth (P)	3.28	ft	1.00 m
Treatment Radial Penetration Depth (P)	39.37	inches	
Outer Circumference of Treated Rock	84.92	inches	
Volume of Rock (π/4/144)*[(P+P+D)^2-(D)^2]	39.1	ft^3/ft	
	292.7	gals/ft	
Porosity of Rock (fraction)	0.2		
Volume of Pore Space in Rock	58.54	gals/ft	
Volume of Pore Space in Rock	1.3938	bbls/ft	
Number of Feet of Perforations	6.6	ft	2.01 m
Volume of Treatment	9.20	bbls	1.46 m3

Volumes Design

Fluid Schedule	Fluid Pumped	CT Rate		CT Position
		Bbl/min	Lt/min	
Pre-flush 1	Brine + Surfactant	0.5 – 1	79 - 159	Circulating & Squeeze & Reciprocate
Pre-flush 2	Brine	0.5 – 1	79 - 159	Squeeze & Reciprocate
Main Treatment	ICABECER	0.5 – 1	79 - 159	Squeeze & Reciprocate
Post flush	Brine	0.5 – 1	79 - 159	Squeeze & Reciprocate
Displacement	Nitrogen - To a stabilized injection pressure for 10 mins or max 30,000scf	500 Scf/min		Squeeze & Reciprocate
POOH CT	Nitrogen - If required	Minimum rate		Squeeze & Reciprocate

Placement Methodology

Treatment Placement

Sand Cleanout

- Coiled Tubing
- Foam

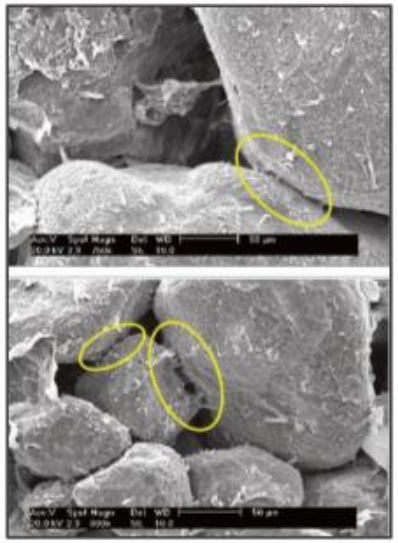
Sand Consolidation

- Coiled Tubing reciprocating
- Pre-flush + ICABECER + Post-flush

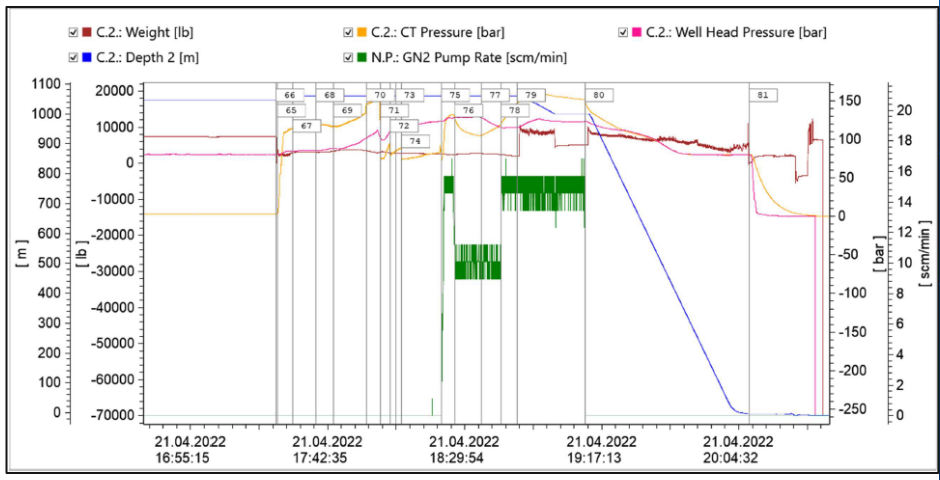
Displacement

- Coiled Tubing reciprocating
- N2 (stable injection pressure)

Sand circulated/lifted out of the well



Photomicrographs of consolidated samples of core material



Pumping chart

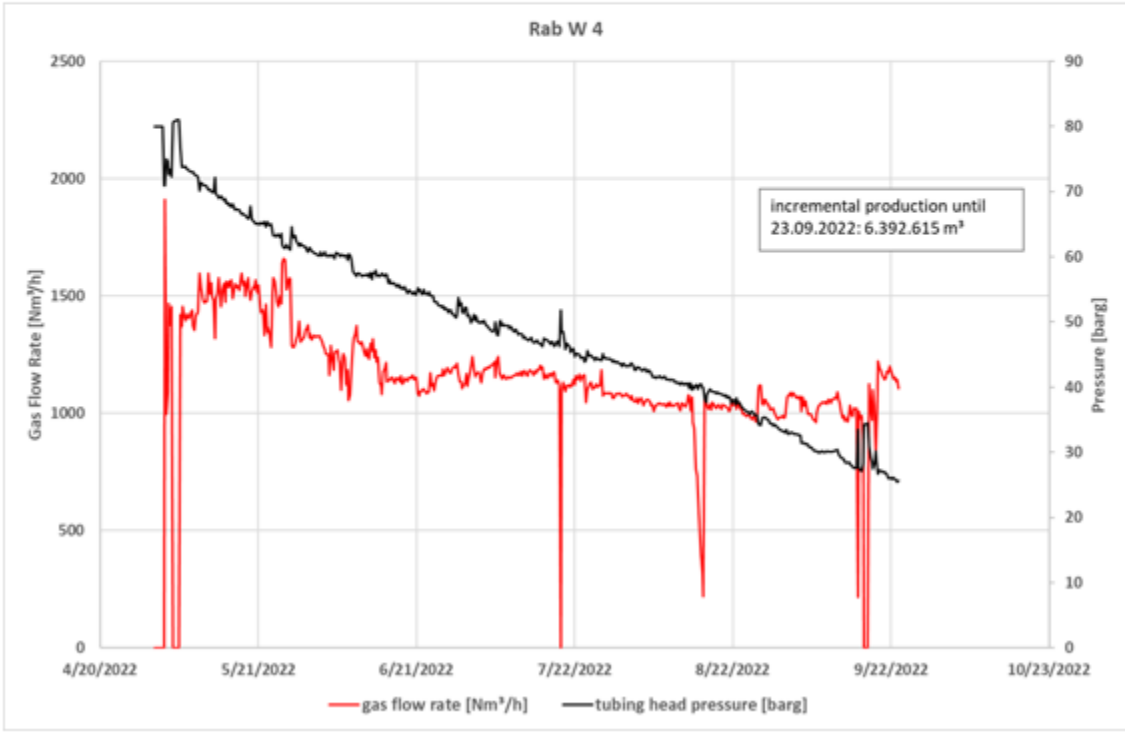
Results

Candidate Selection → Intervention Selection → Laboratory Testing → Intervention Execution → Well Start-up → Well Production → 2-3 weeks Payback → Water Production → Fines Production / Well Shut-in → Investigation and Treatment Improvement → Candidate Selection

Well Start-up: Minimum amount of fines followed by sand free production

Well Production: Initial well production rate & 15% cumulative gas production

Economical success with room for improvement



Gas flow rate and tubing head pressure since the sand consolidation job

Conclusion

- **Technical**
  - Reliable? remedial sand control with significant potential for near future field development in Austria
    - Gas lifted oil well cases: 1 successful, 1 failed
    - Gas well cases: 2 successful (same well), 1 failed
    - Oil well with sucker rod pump case: 1 not conclusive job
  - Keys for success: Candidate selection & Treatment placement
  - One-component system: Simplified treatment placement & Increased chances of success

- **Economical**
  - Very short payback of intervention cost (2-3 weeks)
  - Incremental revenue

- **Improvement**
  - Water production caused recurring fines production after around six months, causing the treated well to be shut in again

Potential Future Use of Technology

- **Gas storage wells with failed screens**
  - Temporary solution until completion change