TERRATEC

Well Stimulation&EOR Technologies

REACTIVE CHEMISTRY – STIMULATION TECHNOLOGY

REACTIVE CHEMISTRY

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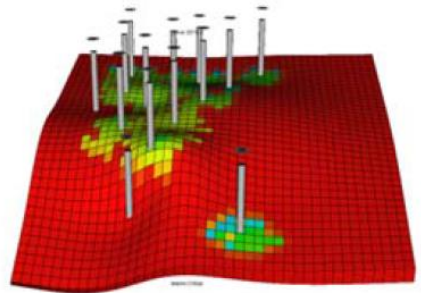
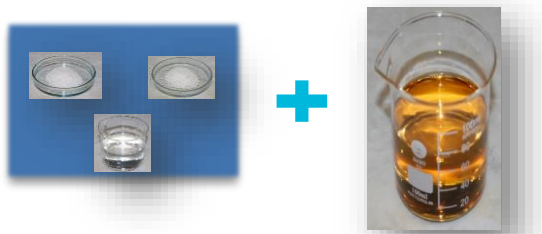
Objectives

- New technology approach for production stimulation. Creating high downhole temperature and pressure that impact on reservoir properties and its ability to produce



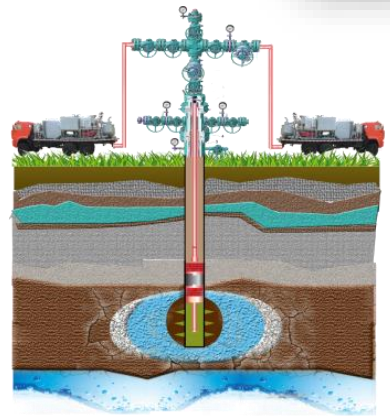
Solution

- The injection of stable aqueous solution of salt and oxidizer Reaction will create heat at the reservoir that will provide changes of oil viscosity to improve it mobility, as well as provide clean-up of near-wellbore reservoir that will improve well production performance, by reducing skin factor.



Approach

- Safe and proven application. Delivery of reactive chemistry into reservoir. Reaction occurs away from well bore that eliminate any impact on wellbore and surface equipment



REACTIVE CHEMISTRY – MAIN STAGES

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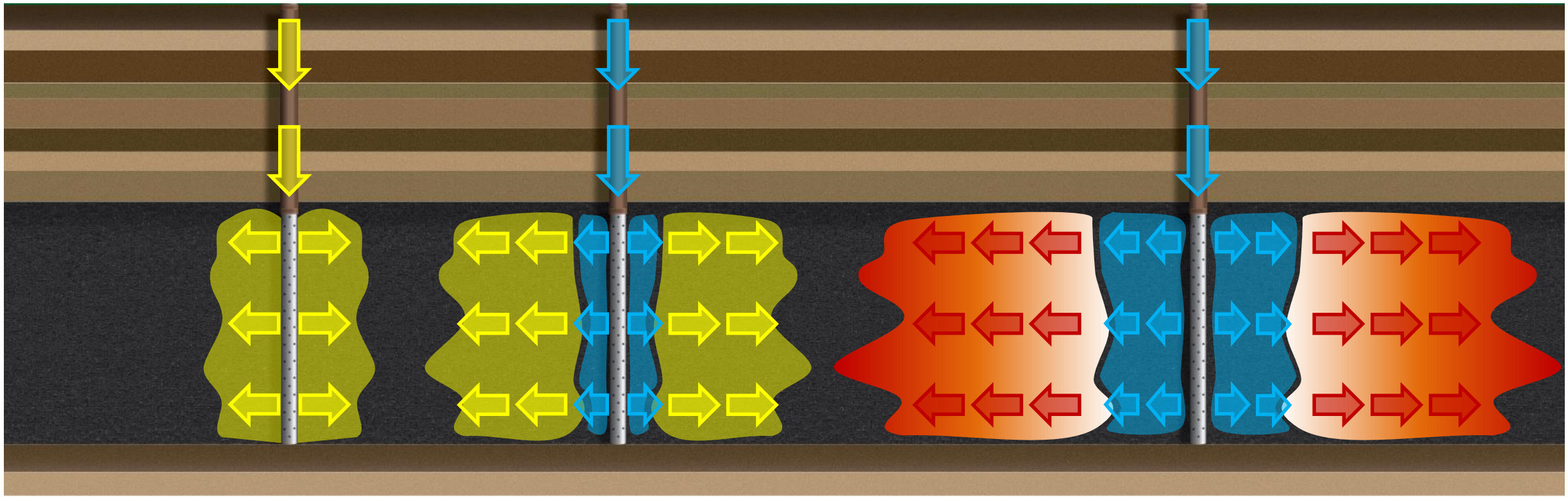
1st stage **2nd stage** **3rd stage**



Injection of RC into the reservoir.

Beginning of overflush RC into the reservoir.

Overflush RC into reservoir. Beginning of reaction.

RC (inactive) overflush RC (active)

Chemical Reaction

$$COSA(aqua) + COSB(aqua) \rightarrow CO_2\ (gas) + N_2(gas) + 2H_20(liquid)$$

sodium nitrite

ammonium nitrate

Products of reaction don't need to remove it from the oil after treatment

Control Parameters

PRESSURE
Controlled by Reaction Rate

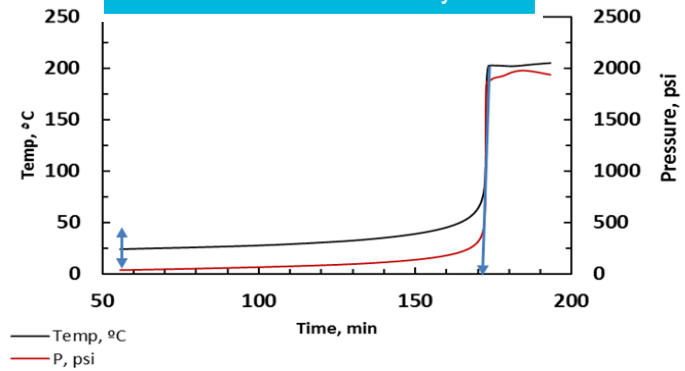
REACTION TEMPERATURE
Formulation Design

TOTAL HEAT VOLUME
Controlled by Treatment Volume

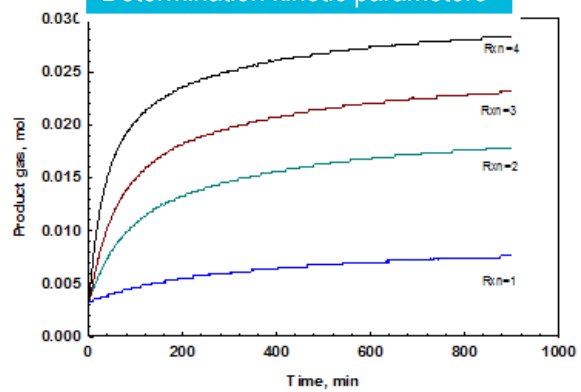
REACTION TIME
Delaying Agent

Binary Solution + Stabilizer + Actuator

Determination reaction delay time



Determination kinetic parameters



PRODUCTION STIMULATION OF NEW AND EXISTING WELLS

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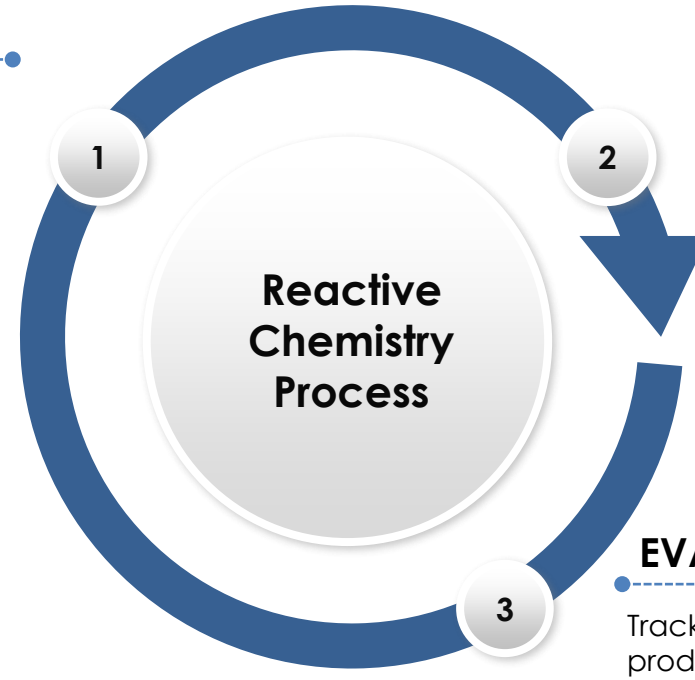
An engineered aqueous solution is injected into the reservoir to create a controlled increase in the bottom-hole temperature (BHT) and pressure. This chemistry optimizes the field development plan, improves oil recovery and reduces the total cost of field production.

Benefits

- PRODUCTION INCREASE
- SAFE HANDLING-STANDARD CHEMICAL USAGE PRACTICE
- SMALL EQUIPMENT FOOTPRINT
- RIGLESS OPERATION
- CONTROLLED REACTION, BEHAVIOR

DESIGN

Review the application envelope, complete candidate selection process and identify the treatment wells. The engineered chemistry will be designed and planned to meet the desired outcome.



EXECUTE

Set-up and complete the job as per the job design. Monitor the initial treatment results and remove equipment from site.
Record critical parameters

EVALUATE

Track and monitor the well production. Review the data and treatment area for residual benefits. Determine if results were as expected.
Correct treatment design based on received info if needed

DESIGN: CANDIDATE SELECTION

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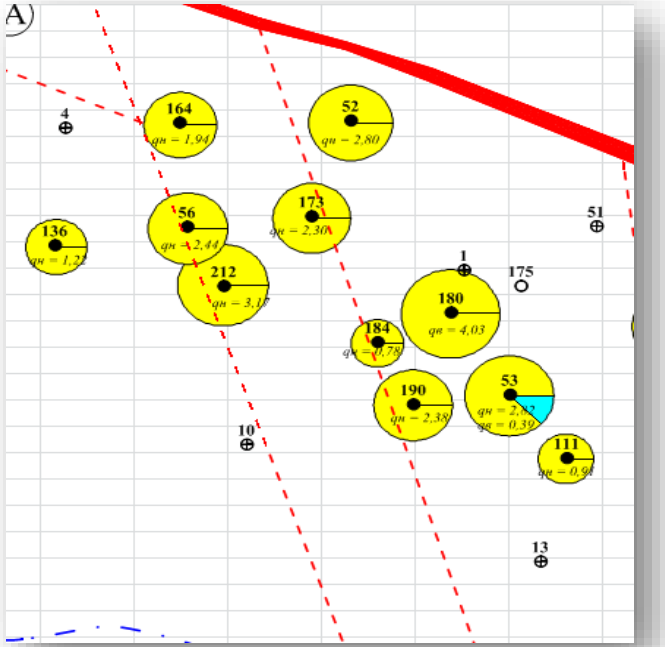
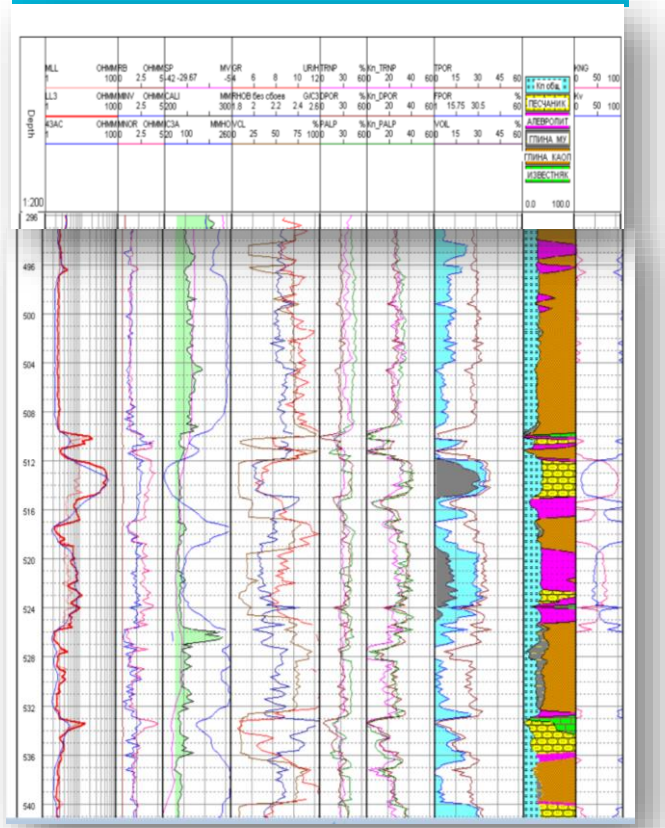
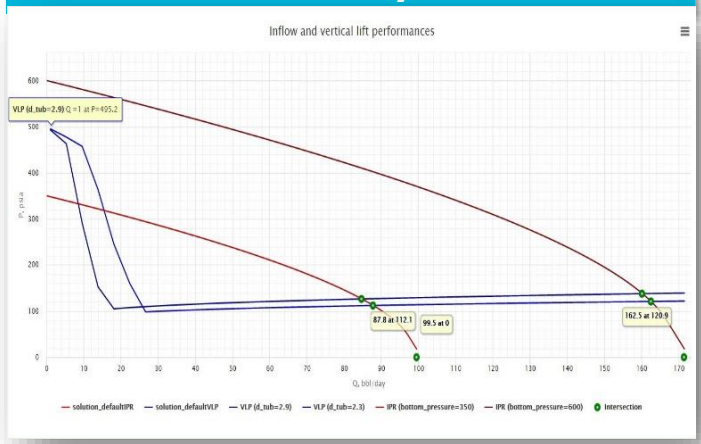
Field Evaluation



Reservoir verification



Production analysis



DESIGN: JOB PLANNING

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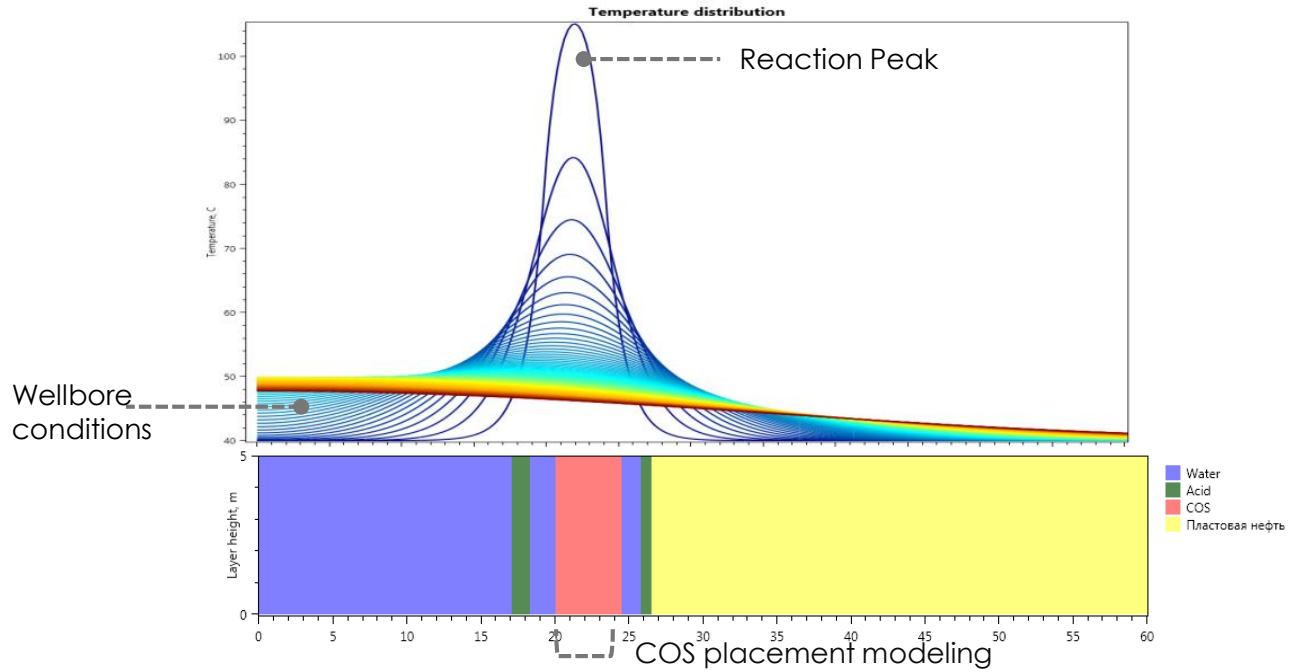
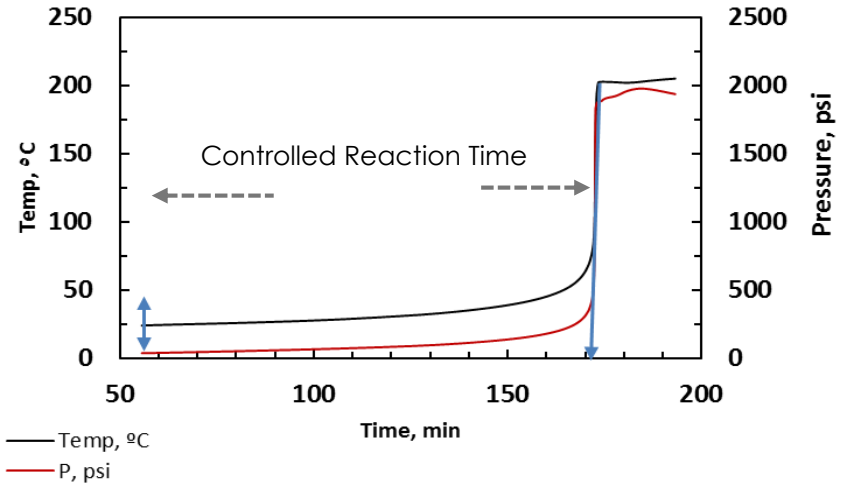
STIMULATION PARAMETERS

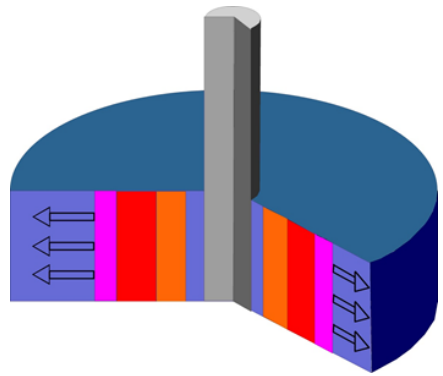
- Maximum allowable wellbore temperature
- Completion limitation
- Fluid volume
- Placement technique
- Optimum reactive chemistry systems performance (time/pressure/temperature)

MODELING

- In-house developed software
- Model validated during field testing
- Post job evaluation
- Technical constraints
- Provides estimation of system placement in the reservoir
- Provide temperature profile after treatment
- Provide pressure distribution after treatment







EXECUTION: RIG-UP SCHEMATIC

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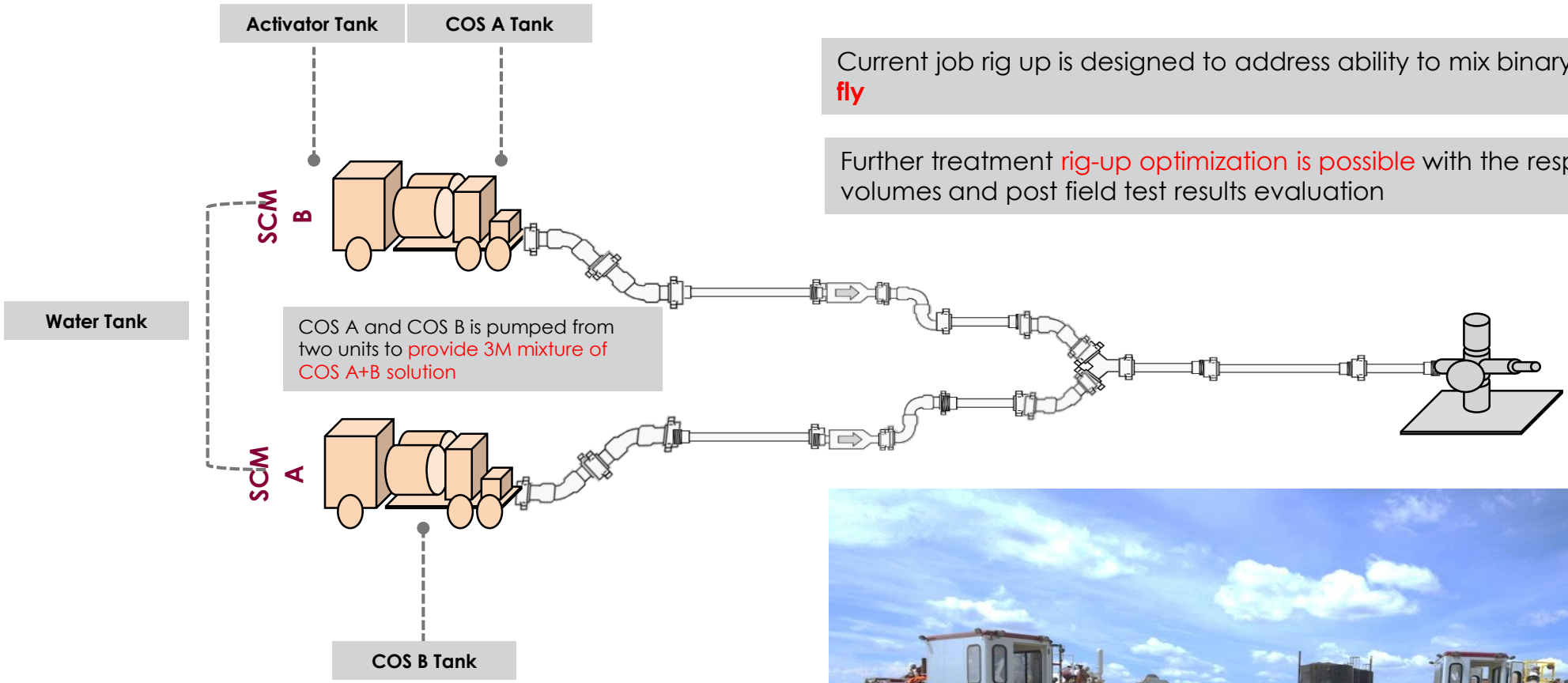

Current job rig up is designed to address ability to mix binary systems **on-fly**

Further treatment rig-up optimization is possible with the respect to job volumes and post field test results evaluation

EXECUTION: RECORDING TREATMENT DATA

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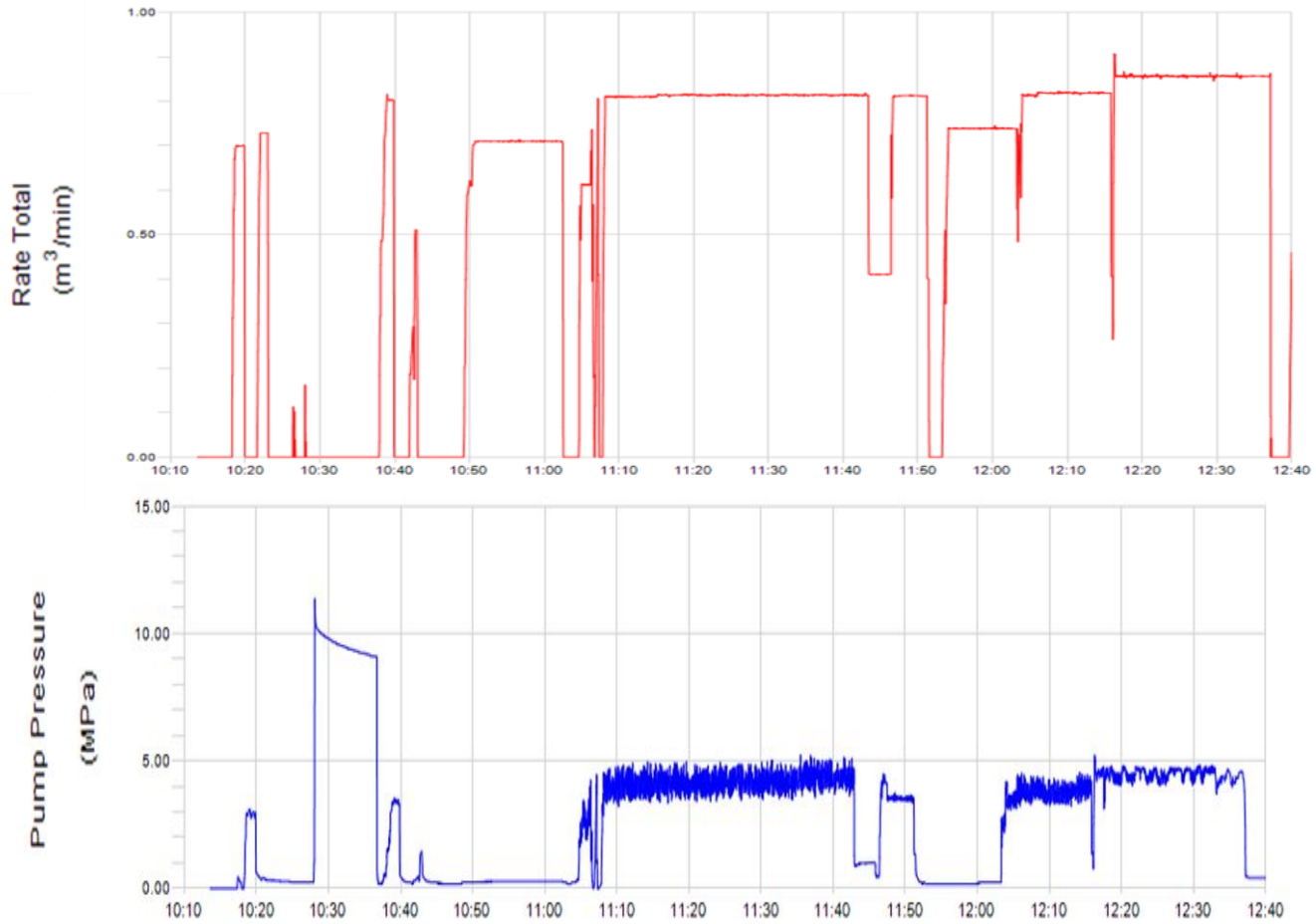
- During the treatment no excessive pressure or temperature to be expected
- Record job parameters
- Further evaluation performed to optimize treatment design

- Small injection rate possible to address limitation of completion
- No impact on surface pressure equipment (well-head)
- No impact on down-hole equipment (COS is non-corrosive fluid)



EXECUTION: RECORDING TREATMENT DATA

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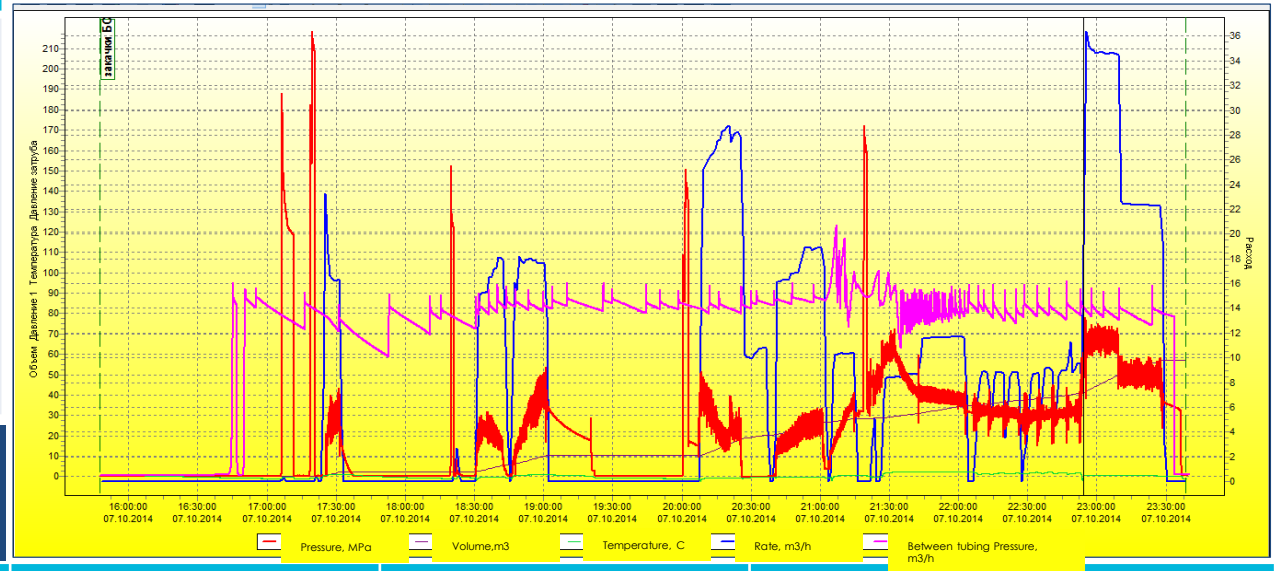
Equipment

Equipment
- Standard pumping equipment in used (usually 1 pump truck)
- Auxiliary equipment (standard equipment is used – tanks)

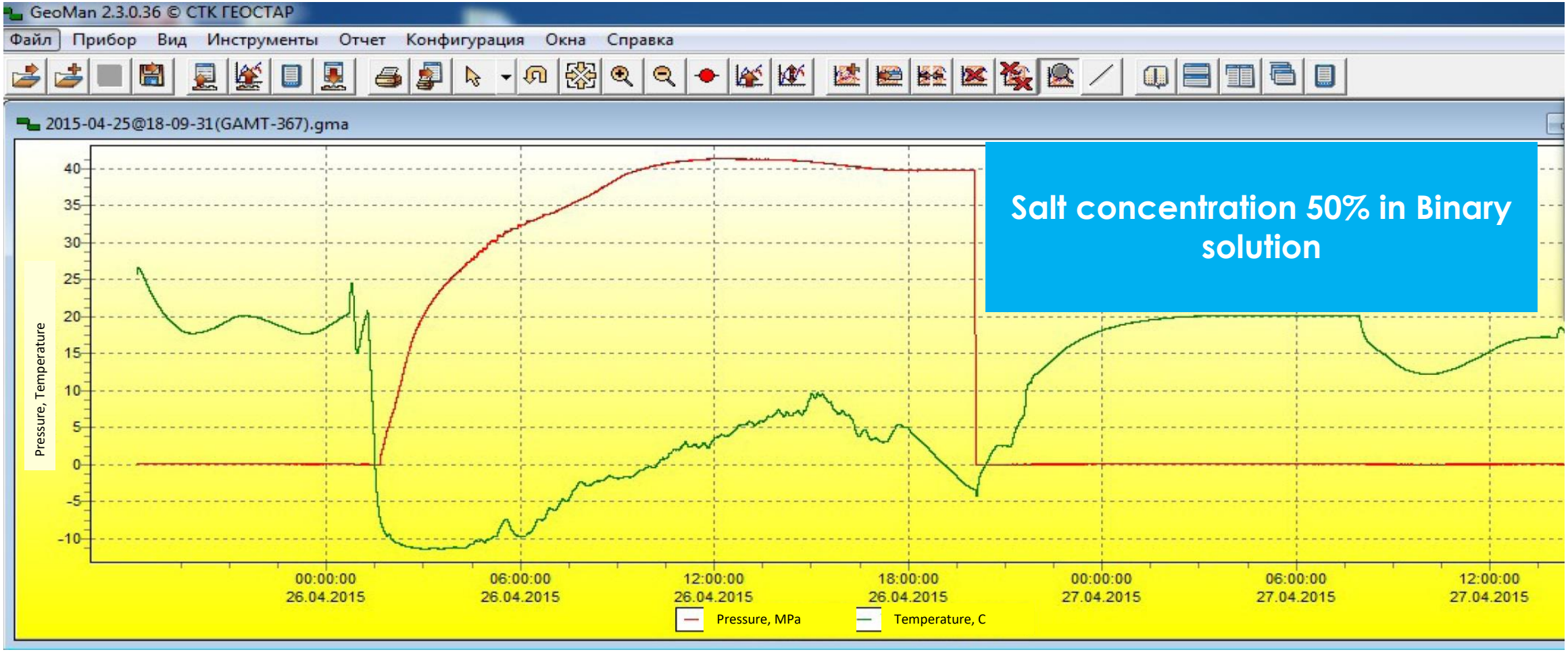
Job parameters recording



Typical stimulation schedule for carbonate formation

Stage	Fluid	Volume* (m3)	Rate (m3/min)	Cumulative Time (min)
1	Water	4	1	4
2	Pickle	2	1	8
3	Spacer	2	1	12
4	COS	30	1	42
5	Spacer	2	1	46
6	Acid (HCL)	2	1	50
7	Flush	20	1	70

Post-Treatment Analysis (X-mas tree sensors)



EVALUATION: SURFACE PRESSURE AFTER THERMAL STIMULATION WITH FRACTURE INITIATION

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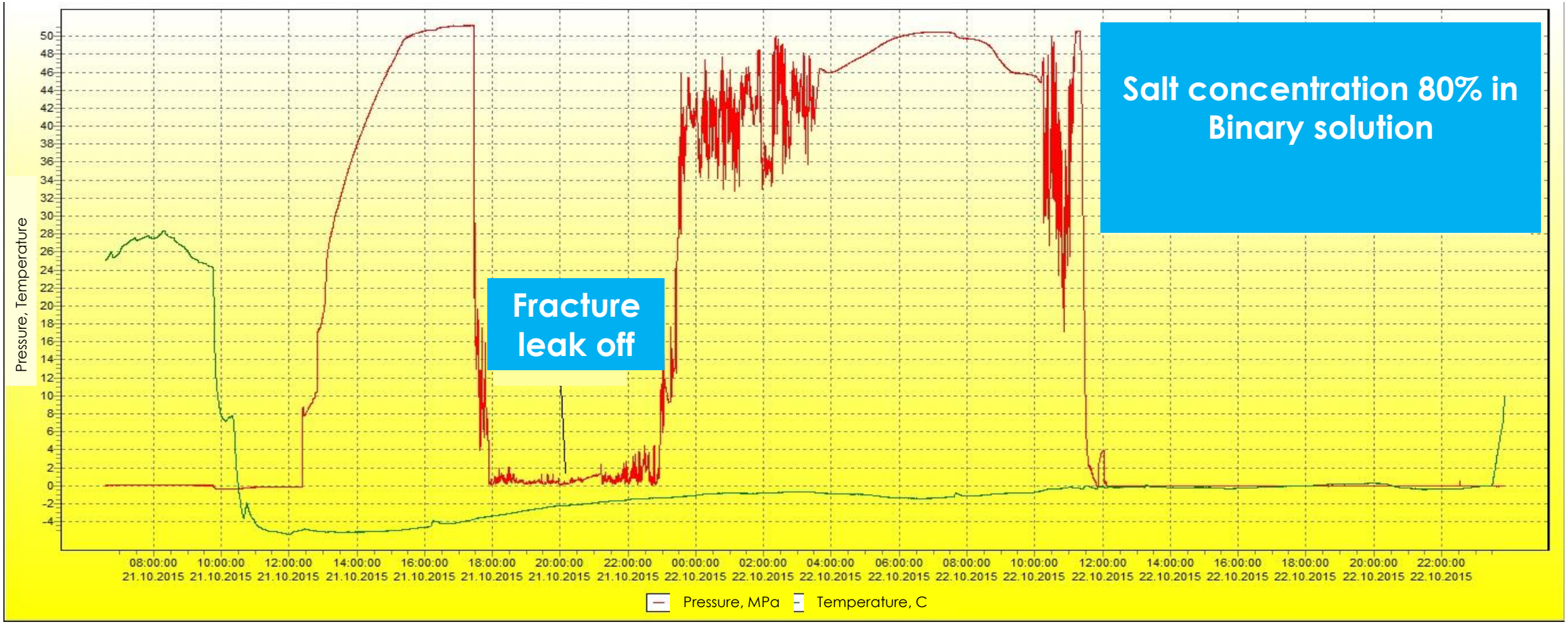
Post-Treatment Analysis (X-mas tree gauges)



EVALUATION: PRODUCTION LOGGING, NODAL ANALYSIS, POST-JOB MODEL EVALUATION

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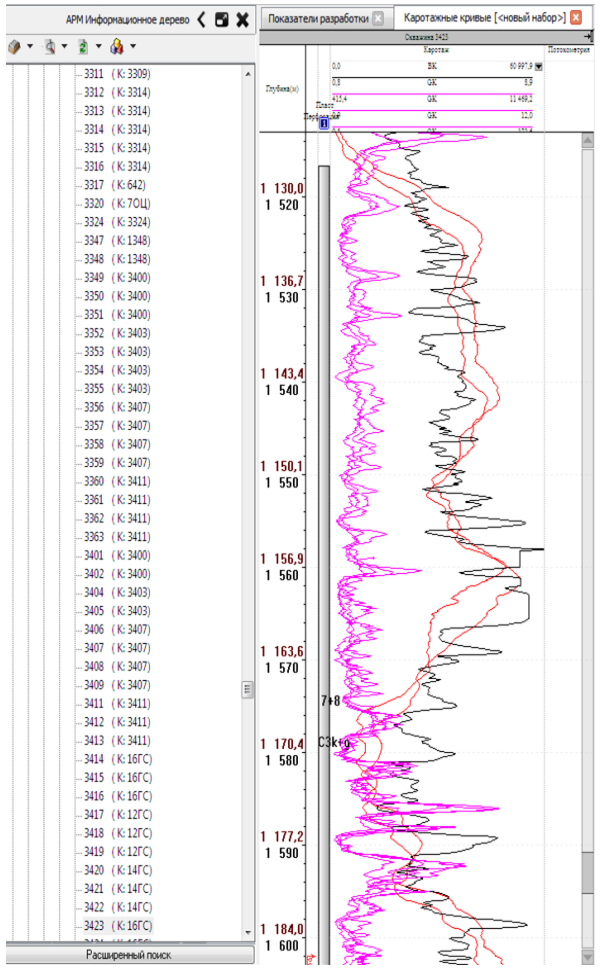
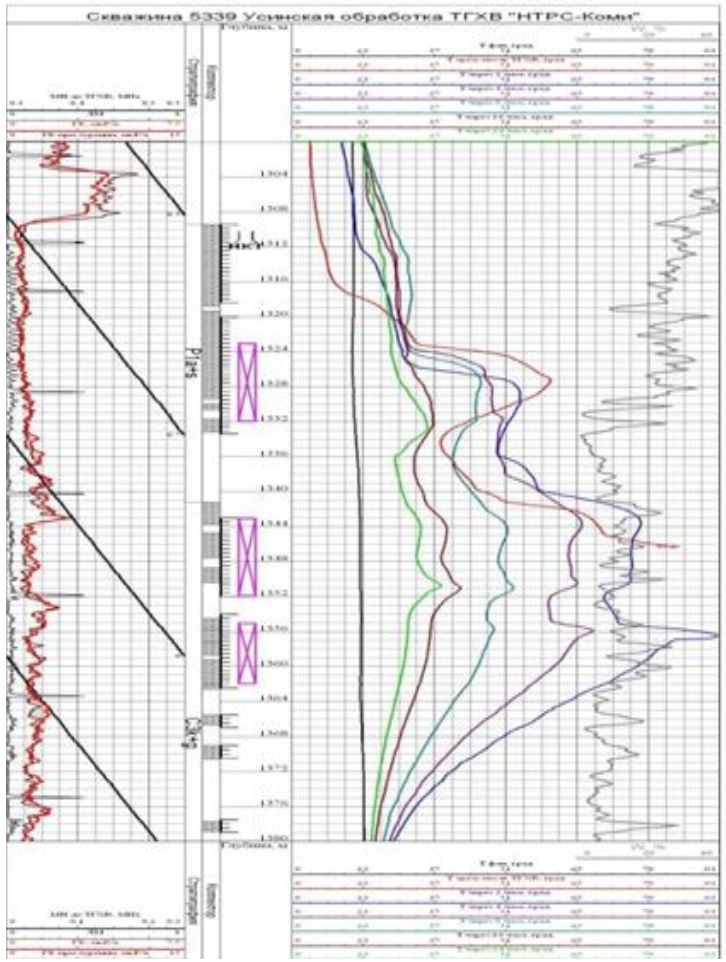
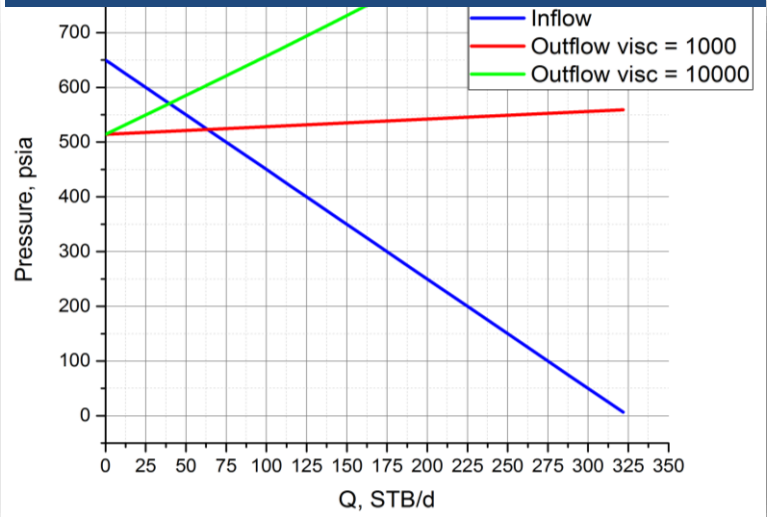
Temperature survey

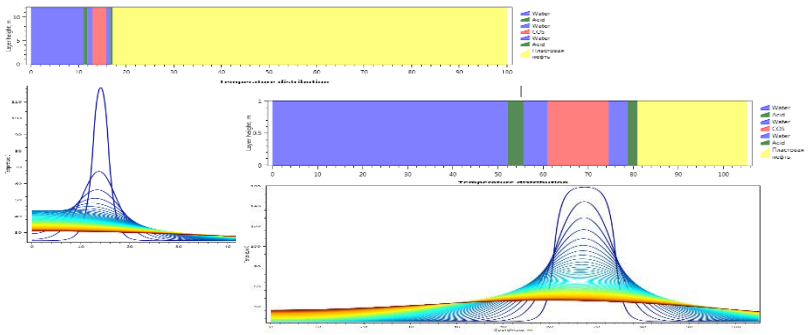




Production analysis and evaluation



Post job model evaluation



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Total treated wells (2008-2017) in Russia **130+** with average IOP **1714 tons**.

RESERVOIR DATA

- Oil gravity: >20° API,
- Formation: Carbonates
- Depth: 1200 -1400m
- BHST: 22 – 30°C
- BHP: 80 bar
- Average volume of released gas – 4 896 st.m^3
- Total heat generated – 61.2 GJ

Clients

LUKOIL OIL COMPANY

ROSNEFT

PUTEK

TATNEFT

Well Number	Pre-treatment Production			Post treatment production			Incremental	
	Qf, м^3/day	WC%	Qoil, m^3/day	Qf, м^3/day	WC, %	Qoil, т/day	Qf, м^3/day	Qoil, т/day
1	0.0		0.0	3.0	10.0	2.8	3.0	2.8
2	4.0	7.0	3.6	14.0	2.0	13.2	10.0	9.6
3	0.0		0.0	8.0	14.3	6.6	8.0	6.6
4	4.0	38.0	2.0	7.2	75.0	1.7	3.2	-0.3
5	8.0	4.0	7.4	18.1	10.0	15.7	10.1	8.3
6	10.0	3.0	9.3	16.5	10.0	14.2	6.5	4.9
7	13.0	3.6	12.1	48.0	10.0	41.5	35.0	29.4
8	0.0		0.0	10.0	50.0	5.0	10.0	5.0
9	0.0		0.0	25.0	5.0	22.4	25.0	22.4

CASE STUDY #1: RUSSIA (CARBONATE)

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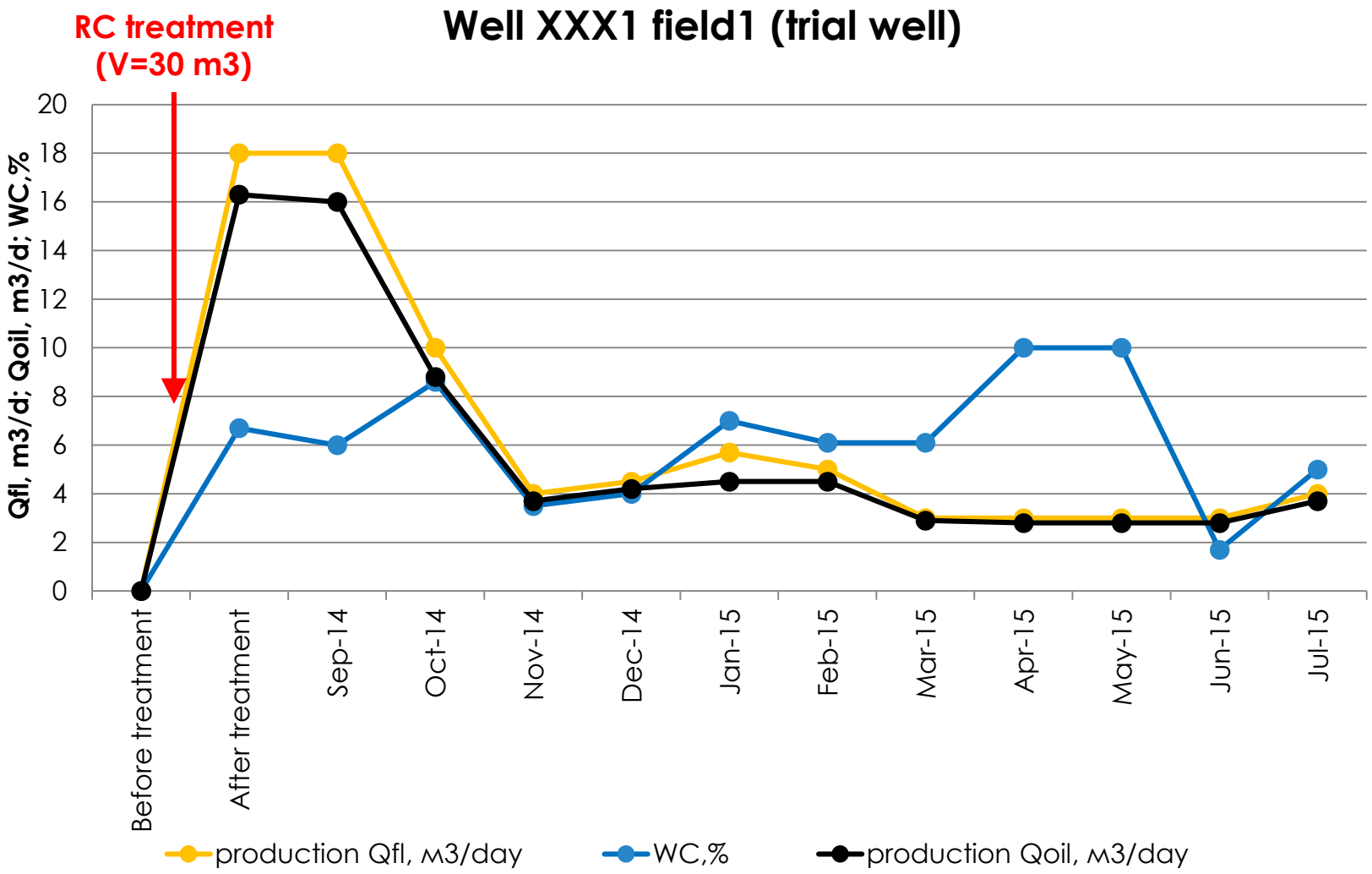

Customer	**«LUKOIL-Komi» Co Ltd.**
Well №	XXX1
Fluid content	Water influx with oil sheen
Deposit	P+C (carbonate)
Type of reservoir	fissured-cavernous
Permeability	3,27 mD
Porosity	19.8 %
Oil viscosity	568 cP
Temperature	23.1 °C
Skin factor	-2,02
Hold-up depth, m	1603.6
Current depth, m	1600
Perforated interval zones, m	1527-1530; 1551-1565,5; 1567,5-1584
Casing OD, mm	168
Downhole equipment	Tubing with funnel (1500 m), packer (1420 m)
Pres, MPa	11,60

Before RC treatment Well#XXX3 was inactive due to unsuccessful previous stimulations. Other methods didn't work. After successful RC trial client started to drill new wells and stimulate with RC at once after drilling.

CASE STUDY #2: RUSSIA (CARBONATE)

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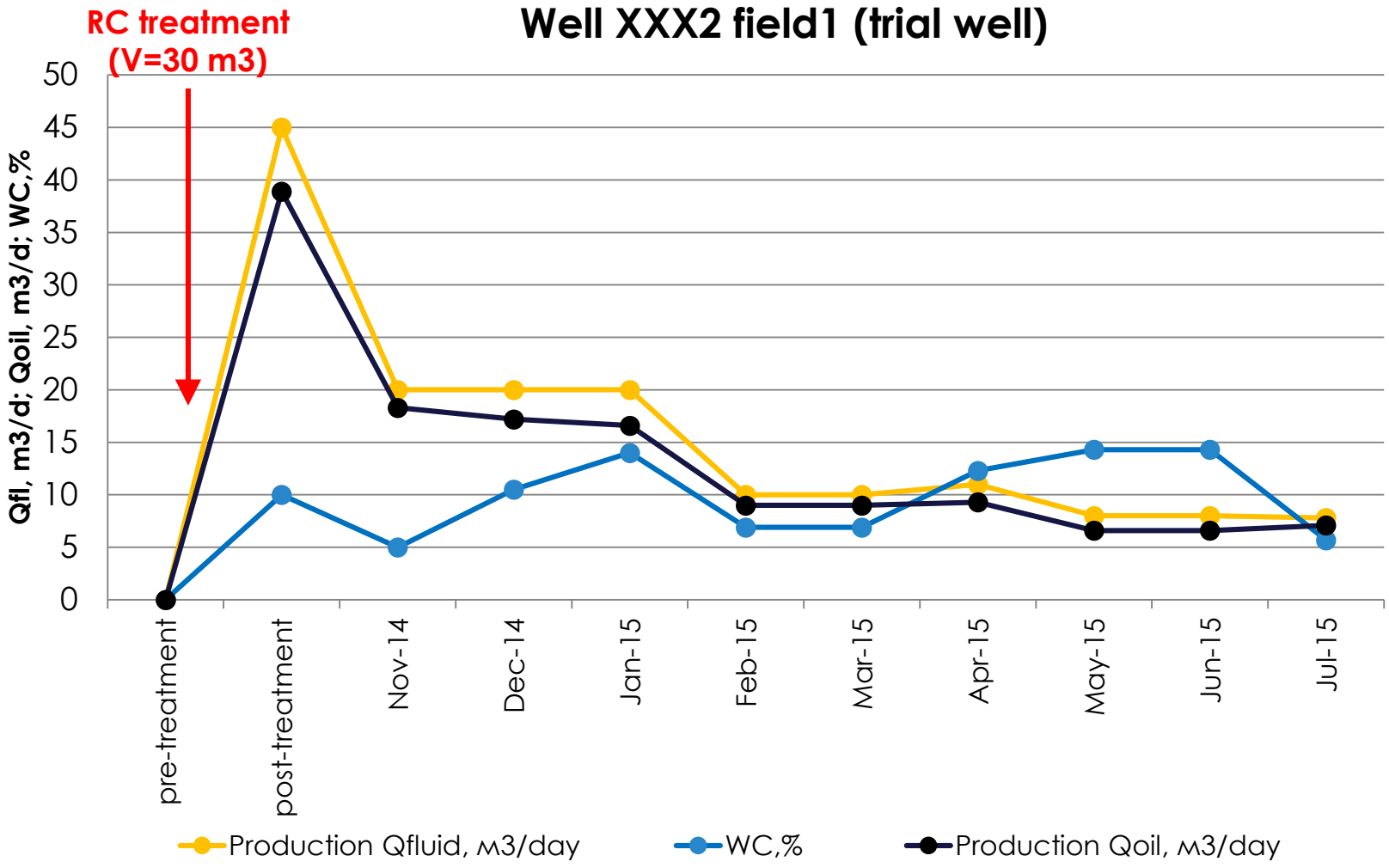

Customer	**«LUKOIL-Komi» Co Ltd.**
Well №	XXX2
Fluid content	Water influx with oil sheen
Deposit	P+C (carbonate)
Type of reservoir	fissured-cavernous
Permeability	550 mD
Porosity	20%
Oil viscosity	620 cP
Temperature	23 °C
Skin factor	n/d
Hold-up depth, m	1436
Current depth, m	1230
Perforated interval zones, m	1181-1227.4
Casing OD, mm	168
Downhole equipment	Funnel, packer
Pres, MPa	7.4

Before RC treatment Well#XXX3 was inactive due to unsuccessful previous stimulations. Other methods didn't work. After successful RC trial client started to drill new wells and stimulate with RC at once after drilling.

CASE STUDY #3: RUSSIA (CARBONATE)

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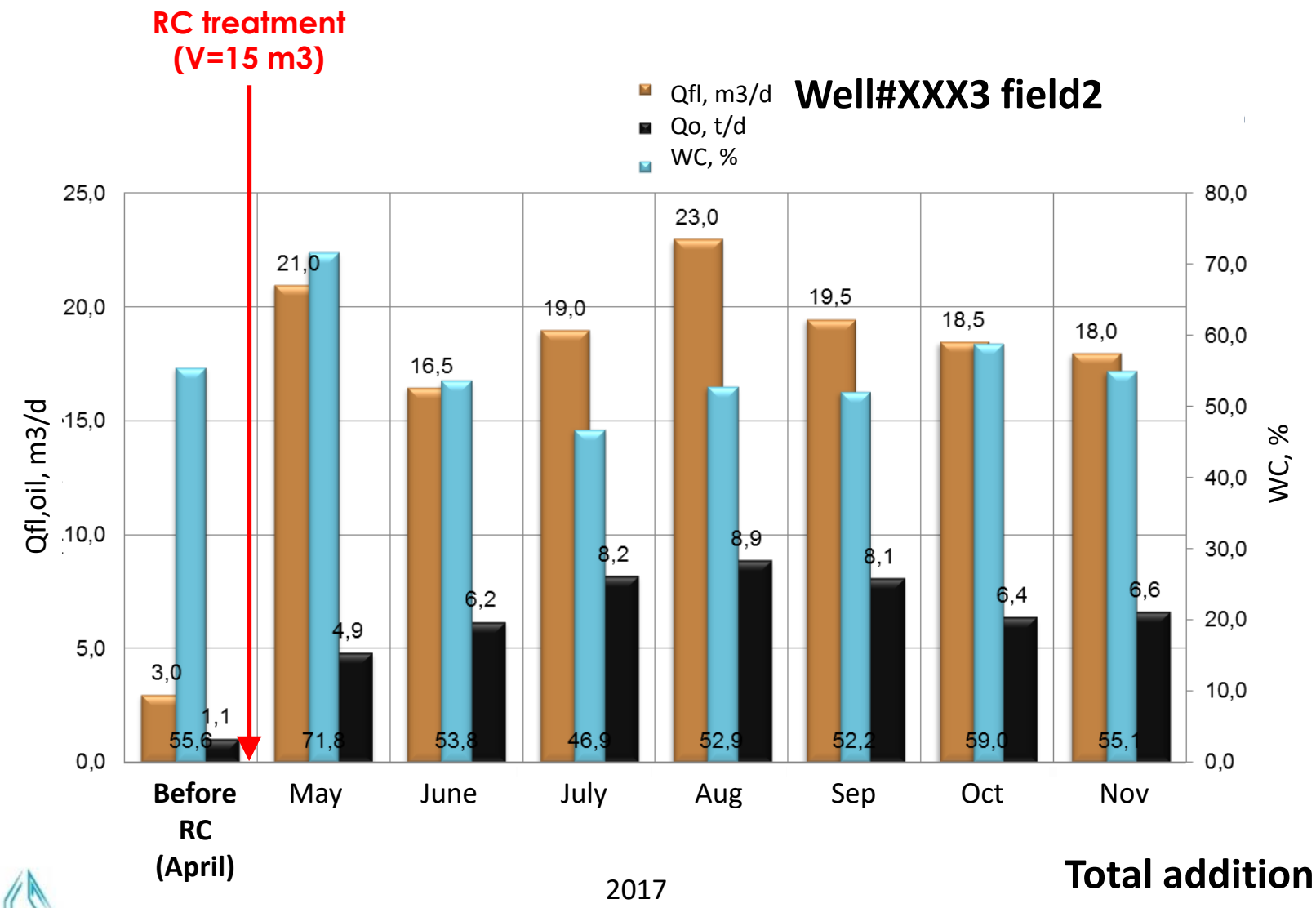

Customer	Rosneft
Well №	XXX3
Fluid content	Water, Oil
Deposit	A (carbonate)
Type of reservoir	cavernous
Permeability	99 mD
Porosity	19%
Oil viscosity	9.8 cP
Temperature	47 °C
Reservoir thickness, m	4.2
Reservoir depth, m	1900
Downhole equipment	Funnel, packer
Pres (initial), MPa	22.4

Total additional oil – more than 1,000 ton

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