



Acoustic Well Stimulation of near-wellbore zone for enhanced oil recovery

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GROUP OF COMPANIES VIATECH

The group of companies specializes in the development of ultrasonic technology and software systems for enhanced oil recovery and own dozens of patents. Engineering company awarded with diplomas of Russian and international exhibitions.

LLC “Viatech” – R&D, manufacturing of ultrasonic equipment

LLC “Sonotech” – Services with permanent treatment solutions on territory of Tatarstan republic from 2014.

LLC «CUT-Services» - Services of ultrasonic treatment on territory of Russian Federation and International projects from 2010



HISTORY OF ULTRASONIC DEVELOPMENT IN VIATECH

Abramov Oleg Vladimirovich (25.02.1936 – 25.09.2008)

Founder of AWS technology, one of first scientists in the world who implemented acoustic fields in the oil wells cleaning application

Scientific background:

1959 – 1975 Central research Institute of ferrous metallurgy

1975 – 1989 Institute of solid state physics, USSR Academy of Sciences

1990 – 2008 Institute of General and inorganic chemistry, Russian Academy of Sciences



His main area of research - the study the influence of power ultrasound to the substance, its practical use in metallurgy, engineering, chemistry for the intensification of heat and mass transfer processes and impact on the structure and properties of materials.

Oleg Abramov was a major, globally recognized expert in the field of interaction of ultrasound with matter. He published more than 250 scientific works, including 7 books and chapters in books (4 of them published abroad – in the United States, England, Germany, Slovakia), more than 220 papers and received more than 30 inventor's certificates. He was the head of the 25 graduate students who have defended PhD thesis, 4 of his students defended their doctoral dissertations.

Abramov Vladimir Olegovich

Lead scientist who driving ultrasonic research all his life.

Co-founder and co-owner of group of companies VIATECH

Scientific background:

1985 – 1993 Central research Institute of ferrous metallurgy

1993 – 1996 Germany, Max-Planck-Institut für Metallforschung, Institut für Werkstoffwissenschaft

From 1996 Institute of General and inorganic chemistry, Russian Academy of Sciences



His main area of research – theory of ultrasonic vibrations, the introduction of ultrasound in metals and alloys, the effect of ultrasound on physico-chemical and technological processes, including wastewater treatment, recovery of oil wells, oil refining and chemical conversion to oil products.

Vladimir Abramov is the author of over 100 scientific publications and patents.

Ultrasonic equipment and technology cycles, developed under the leadership of Vladimir Abramov, implemented and are successfully functioning in Russia and more than 25 foreign countries.

LLC «CENTRE OF ULTRASONIC TECHNOLOGIES - SERVICES»

Service base of LLC «Centre of Ultrasonic Technologies - Services» is located on the territory of 23 375 m²

Located on the territory:

- Administrative building – 375 m²
- Workshop – 1600 m²
- 2 Arched Warehouses – 800 m² each
- The base is equipped with its own boiler, water supply system, a backup diesel generator

Abilities:

Up to 100 AWS operations monthly by 5 mobile fleets

Unit 1 based on Ural 4320 – from 2011

Unit 2 based on Ural 4320 – from 2012

Unit 3 based on Kamaz 43118 – from 2013

Unit 4 based on Kamaz 43118 – from 2014

Unit 5 based on Ural 4320 – from 2015



TREATMENT OF WELLS WITH LIGHT OIL

ISSUES ASSOCIATED WITH OIL RECOVERY REDUCTION

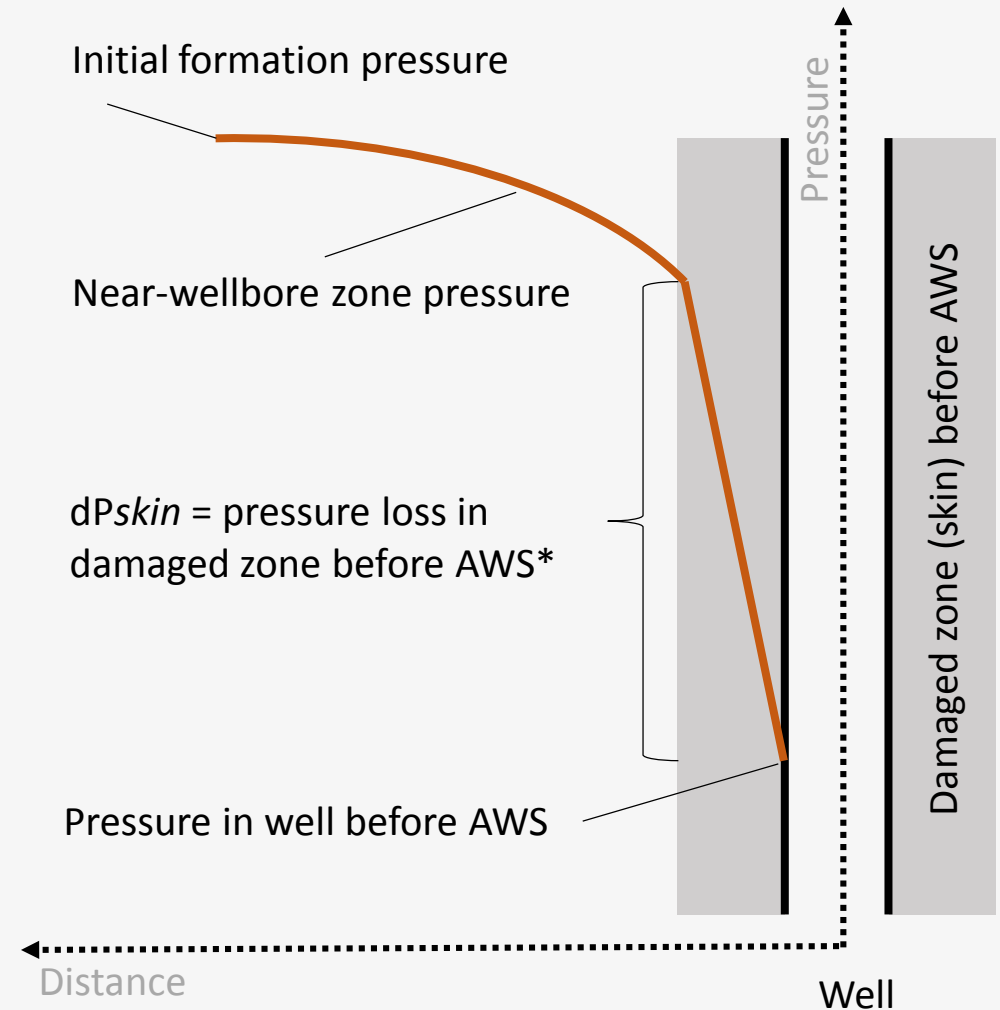
Decrease the permeability of the near-wellbore zone may be caused by many factors, which depends both on the properties of the rock and the mode and technology of well operation, including the most common causes of declining productivity of wells can be:

- Mudding of a near-wellbore zone of the reservoir during drilling a well
- Mudding of a near-wellbore zone of the reservoir during well life (waxing, skin increase)
- Formation of crust in perforation channels after cumulative perforation
- Clogging of perforation channels and pores of rock during the process of killing the well and subsequent increase of pressure gradient between formation and the wellbore

NEAR-WELLBORE ZONE CLEANUP AFTER DRILLING

- Destruction of the boundary layer, confining globule mud filtrate and other particles in the rock pores
- Removal of contaminants from the rock
- Improving communication of well - formation system
- Improving well productivity from the first hours
- Preserving effect up to 2 years during continuous flow from the well

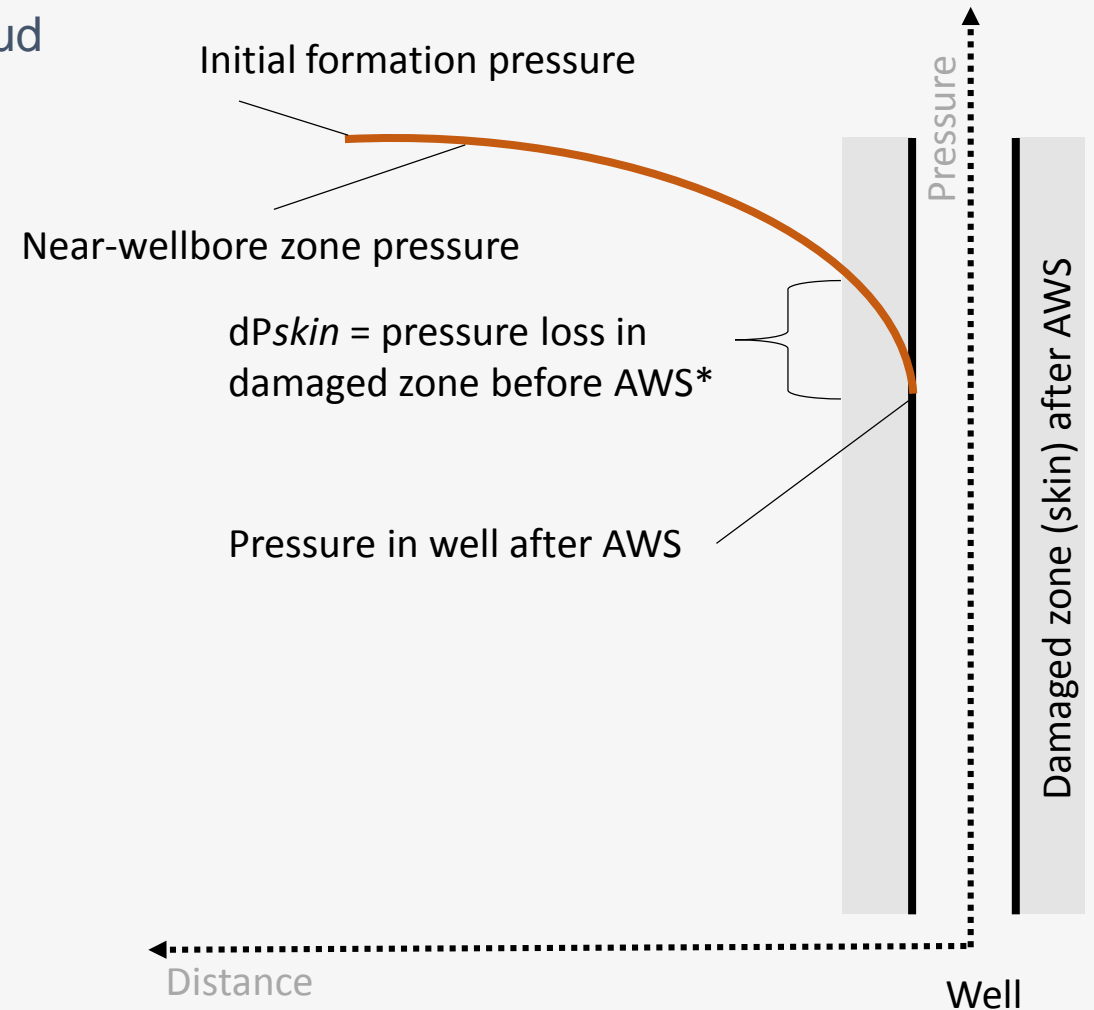
Reducing resistance of near-wellbore zone
=
Productivity increase



NEAR-WELLBORE ZONE CLEANUP AFTER DRILLING

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Reducing resistance of near-wellbore zone
=
Productivity increase



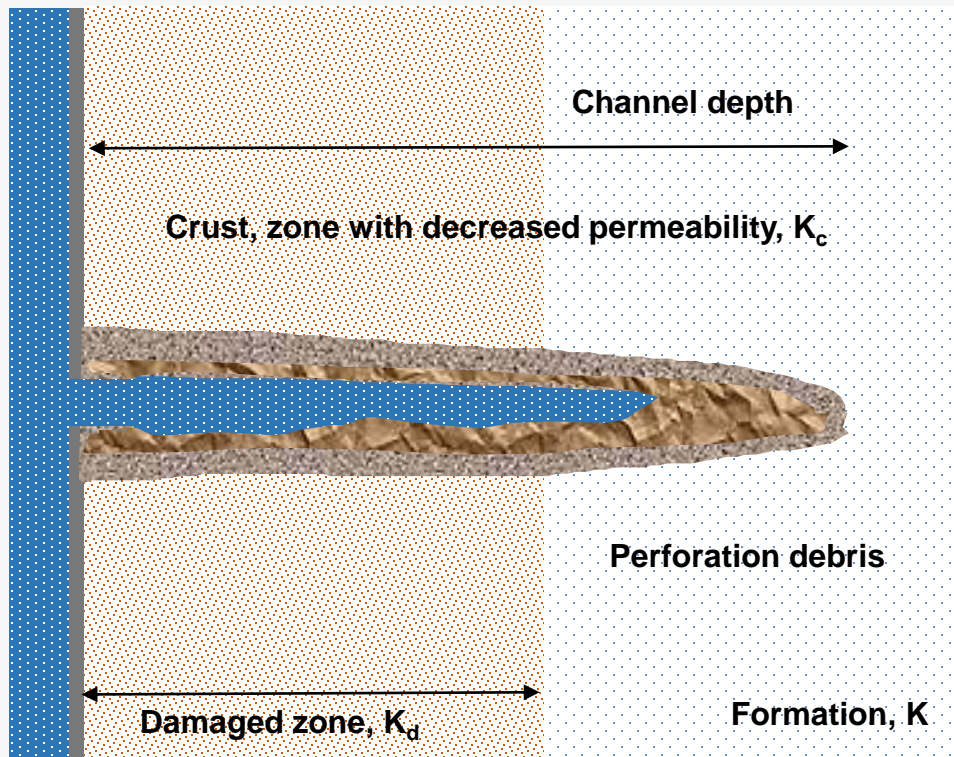
CLEANING OF PERFORATION CHANNELS FROM THE DEBRIS AND CRUST

- Destruction of the boundary layer, confining particles of debris in the perforation channels
- Detachment crust formed by the cumulative jet, from the rock in the perforation channel
- Required to ensure well flowing during AWS to clean perforation channels from debris and crust
- Improving communication of well - formation system
- Improving well productivity from the first hours
- Preserving effect up to 2 years during continuous flow from the well

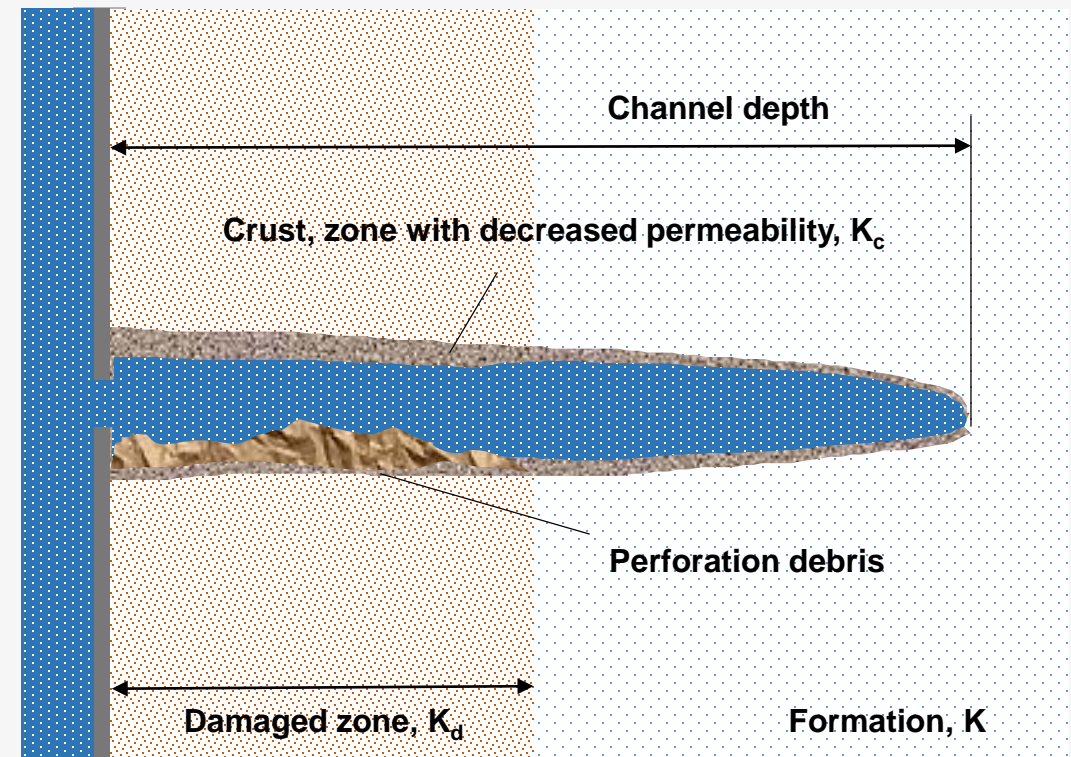
Reducing resistance on the boundary of perforation channels
=
Productivity increase

CLEANING OF PERFORATION CHANNELS FROM THE DEBRIS AND CRUST

Perforation channel after perforation



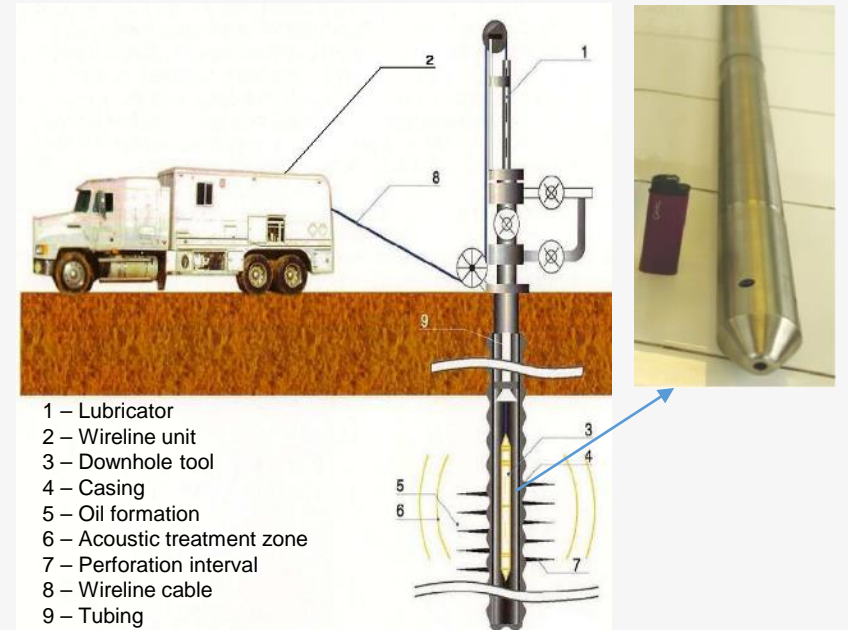
Perforation channel after AWS with underbalance



- A significant increase of the inflow area of perforation channels increasing well production
- In addition to the removal of the crust, there is a cleaning of the damaged zone of near-wellbore formation

TEMPORARY ACOUSTIC WELL STIMULATION SERVICES

- Operations on the wells with light and moderate oil
- AWS equipment contains surface ultrasonic generator and acoustic well oscillator connected by 3-wired cable.
- The main component of downhole tool is acoustic oscillator (magnetostrictive or piezoceramic), which transform electric power to mechanical vibrations in ultrasonic range.
- Diameter of downhole tool is 42 or 44 mm. Acoustic oscillator run in the well through tubing, power supply provided through wireline cable.



Advantages:

1. High commercial efficiency
2. Production growth 50% and higher
3. Quick operations
4. Environmental & ecological safety
5. Unlimited iterations on each well
6. Continuous effect from 6 to 24 month

CAPABILITIES OF ULTRASONIC TREATMENT

EXAMPLE: Light oil

30 Bar underbalance, Liquid flowrate 30 m³/day

Performing AWS after killing a well or long standby

Decreasing flowing pressure with saving production

25 Bar underbalance, Liquid flowrate 30 m³/day

- Reducing the cost of oil recovery
- Increasing the life period of equipment
- More gentle reservoir development
- CAPEX and OPEX decreasing for field development
- Increasing cumulative production

Increasing production with same flowing pressure

30 Bar underbalance, Liquid flowrate 50 m³/day

- Rapid development of the well/formation
- Short- and Mid- term production increase
- Decrease CAPEX и OPEX related to volume of produced oil

* - for clarity of the overall efficiency, the example shows approximate numbers

WE ARE PROVIDING SERVICES IN DIFFERENT COMBINATION:

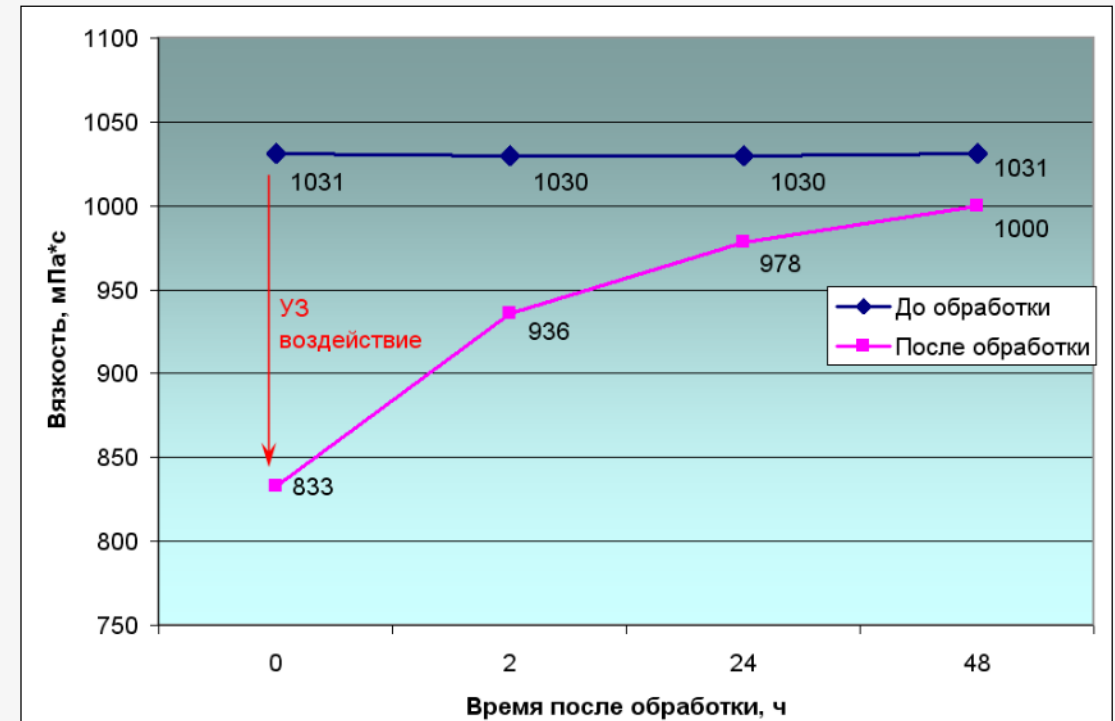
- Acoustic Well Stimulation of near-wellbore zone
- Acoustic Well Stimulation in combination with Chemical injection
(own chemicals developed and patented)
- Acoustic Well Stimulation on Underbalance (Jet pump or Nitrogen unit)
- Combined treatment: AWS + Chemical injection + Underbalance
- Treatment of Injection wells

Client may chose and adopt type of services based on field development program and formation properties

TREATMENT OF WELLS WITH HEAVY AND VISCOUS OIL

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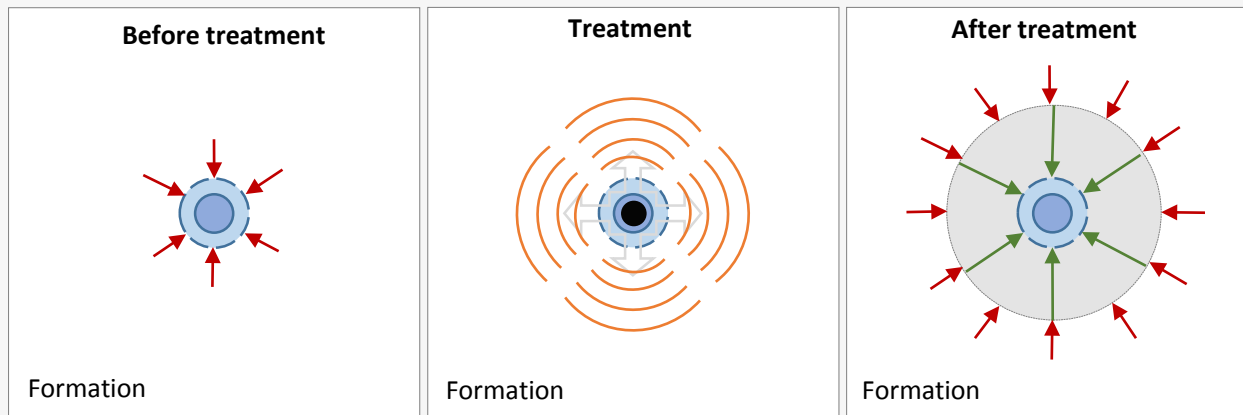
- High-viscosity, paraffin- and asphaltene- containing oil have a non-Newtonian viscoelastic properties
- Ultrasonic treatment changing the viscoelastic properties of oil and approaching fluid to the ideal Newtonian fluid
- The effect is achieved due to the impact at the molecular level and the destruction of intermolecular bonds
- The effect lasts up to 48 hours on treated oil
- In combination with demulsifiers effect may lasts up to 9 days on treated oil



Beneficial effect on oil fluidity and **improving well production** on the same regime of the well

TREATMENT OF WELLS WITH HEAVY AND VISCOUS OIL

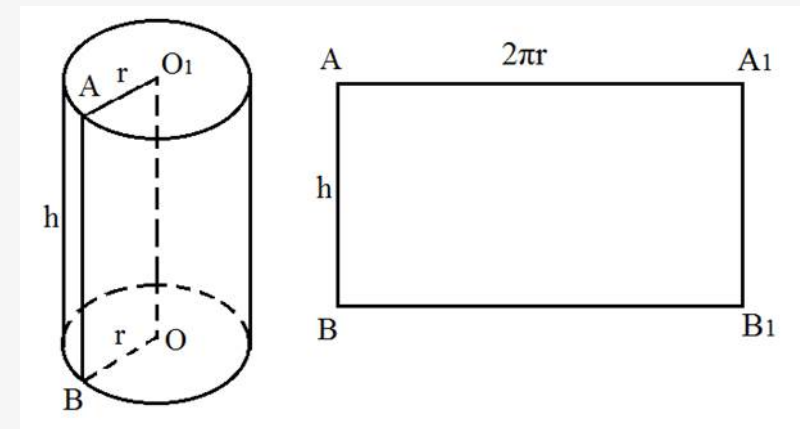
Increase of drainage area and velocity of fluid inflow is an actual and operational solution for oil recovery increase for the wells with heavy and viscous oil



Calculation for 3-meter thickness of prod. interval:

Initial drainage area
 (215mm drilling bit):
 $2 * 3,1416 * 0,215 * 3$
= 4,05 m²

Drainage area
 After acoustic stimulation
 (Radius of impact - 1500mm):
 $2 * 3,1416 * 1,5 * 3$
= 28,27 m²



- Inflow velocity before treatment
- Inflow velocity after treatment
- Area of increased fluid velocity

Drainage area increase ⇒ Productivity growth

LATEST DEVELOPMANTS FOR MAXIMUM EFFICIENCY

A first combined tool was developed and produced in August 2016.
It's combine efficiency of physical and thermal EOR methods!



Advantages of thermo-acoustic oscillator:

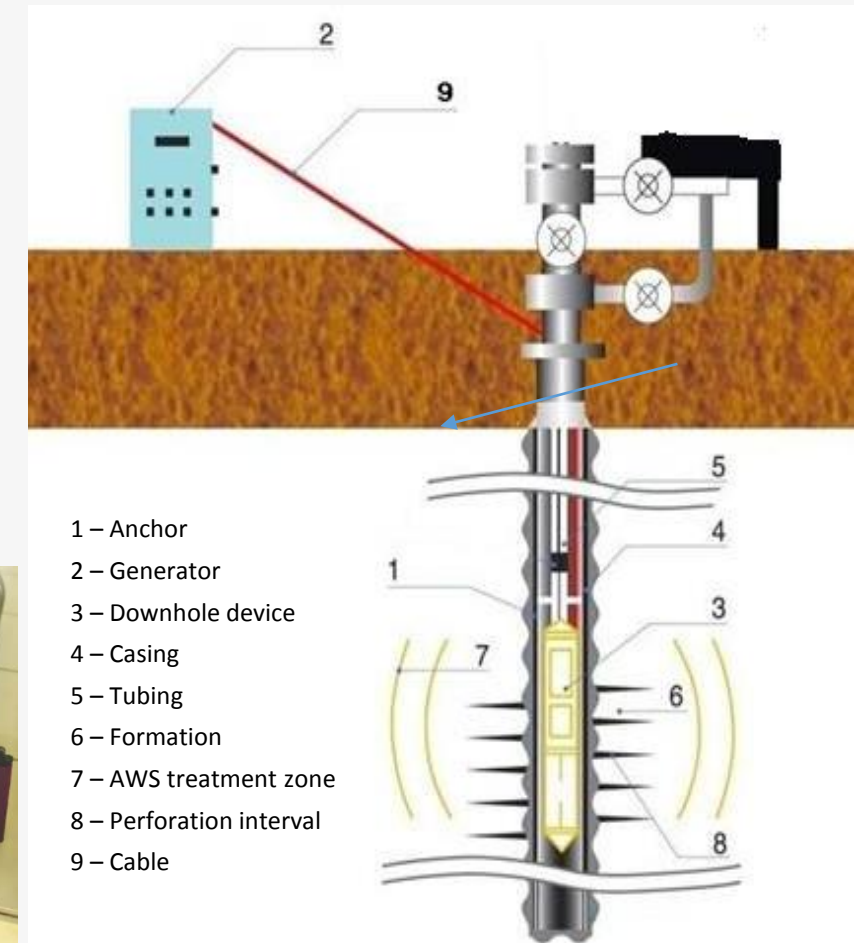
- Breaking down waxes in formation in acoustic field
- Downhole heating of liquid hydrocarbons Нагрев нефти на забое preventing waxes disposition in tubing and surface oilfield equipment
- Significant viscosity decrease increase a lifetime of Sucker Rod Pumps and decrease electricity cost for oil recovery to the surface
- Growth of drainage area increasing hydrocarbons inflow to the well, increasing actual oil recovery
- Periodical powering of oscillator allow to avoid wax disposition in near-wellbore zone and keep increased productivity of the well

AWS SERVICES FOR WELLS WITH HEAVY AND VISCOUS OIL

- Continuous AWS is intended to increase the flowrate of heavy oil
- The device is installed during workover operations on the well
- Downhole tool with diameter 102 mm is attached to the tubing
- Downhole tool remains in the well and operating periodically
- Device is controlled by ultrasonic generator from the surface
- Treatment efficiency can be enhanced by chemical injection into the treatment zone or using different frequencies

We are offering 3 main types of services:

- Continuous AWS
- Continuous AWS with injection of chemicals (own chemicals developed and patented)
- Continuous AWS in combination with heating



ACOUSTIC WELL STIMULATION CAPABILITIES

EXAMPLE: Heavy and viscous oil

| Technology capabilities | Advantages for artificial lift | Advantages for field operator |
|---|---|--|
| Acoustic well stimulation of the wells with heavy and viscous oil | <ul style="list-style-type: none">• Viscosity decrease• Increase of liquid flowrate (better cooling of the submersible pump)• More tender operating mode for equipment• Ability to use equipment with higher performance | <ul style="list-style-type: none">• Increase of oil flowrate from the well• Decrease of oil viscosity• Decrease of oil lifting costs• Ecological & environmental safety |

ACOUSTIC WELL STIMULATION CAPABILITIES

EXAMPLE: Heavy and viscous oil

SRP + AWS



Operating experience:

- Russia: Republic of Tatarstan
- USA

PCP + AWS



Operating experience:

- Canada

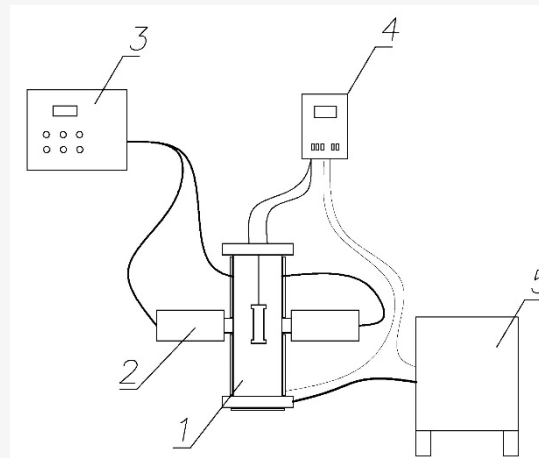
ESP + AWS



Ongoing development

CEMENT-FRIENDLY TREATMENT, PROVEN ON PRACTICE

Photograph and scheme of the experimental equipment used to check the impact of ultrasound on the cement under high pressure and temperature



The experiments on the impact of ultrasound on samples of cement (conducted using the standard method ГОСТ 1581-96 on the device МИИ-100) confirmed, that **ultrasound with the intensity 10 times higher** than the intensity of used during treatment of wells **don't affect the integrity of the cement**

| № of the sample set | Pressure, atm | Temperature, °C | Time of ultrasonic treatment, hrs | Bending strength, kGs/cm ² |
|---------------------|---------------|-----------------|-----------------------------------|---------------------------------------|
| 1 | 1 | 20 | Not | 5,25 |
| 2 | 90 | 80 | 2 | 5,26 |
| 3 | 90 | 80 | 4 | 5,25 |



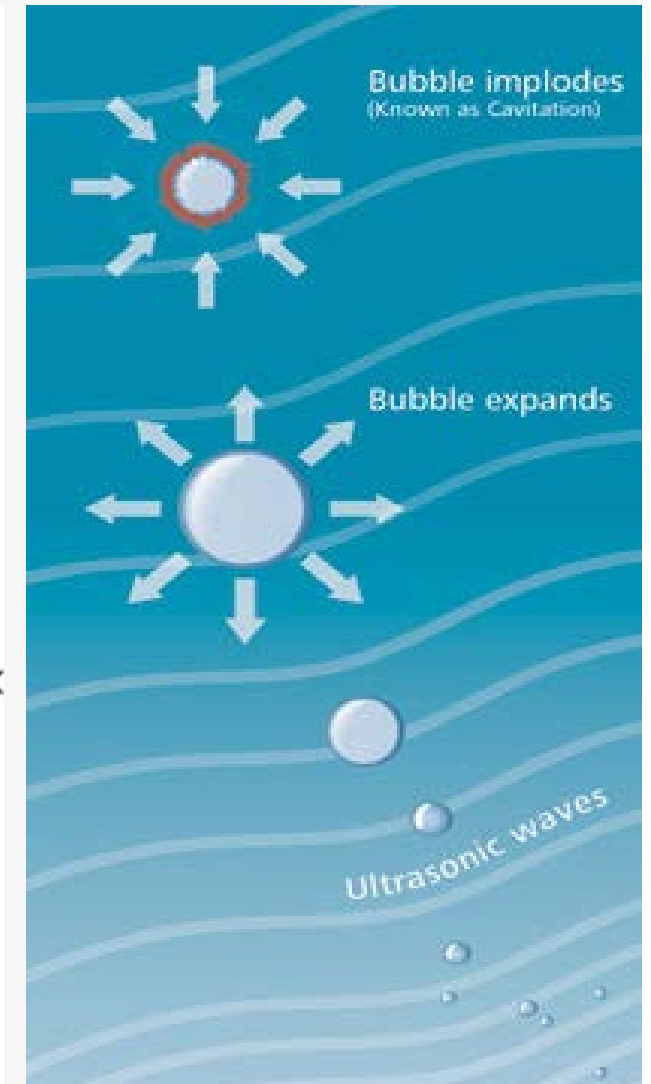
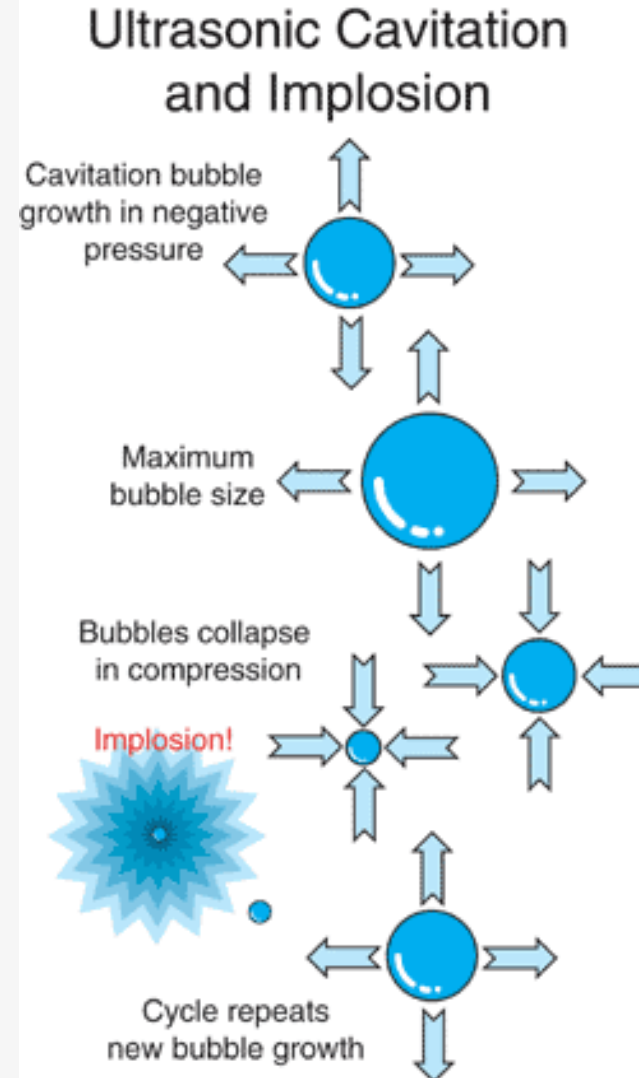
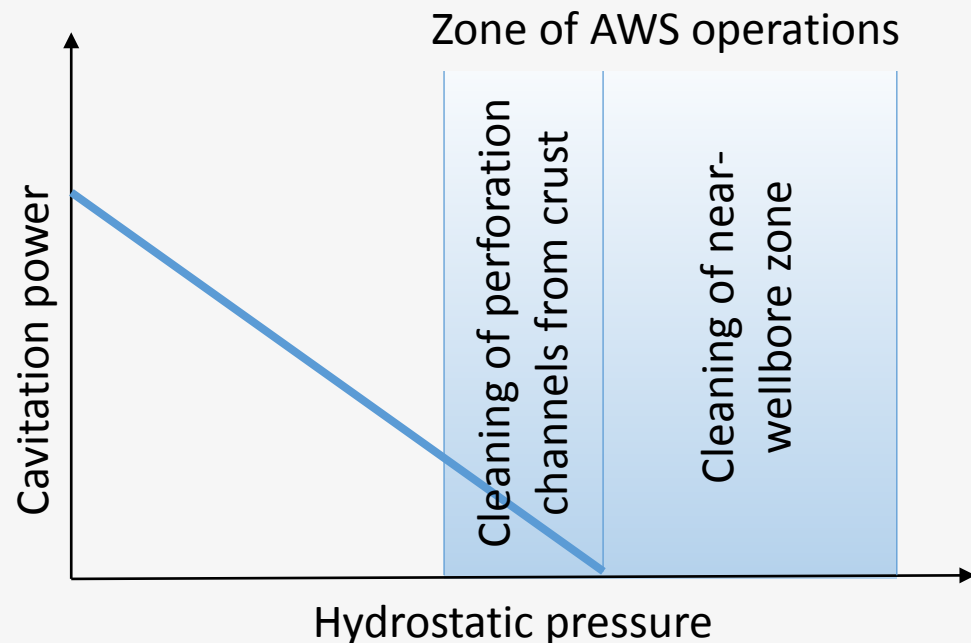
Samples before and after the experiments

PHYSICAL PROPERTIES OF ULTRASONIC EXPOSURE

PHYSICAL PROPERTIES OF ULTRASONIC EXPOSURE

1. Cavitation

Ultrasonic cavitation — the formation and activity of gas bubbles in the area exposed to ultrasound, as well as effects arising from their interaction with the environment and acoustic field.



PHYSICAL PROPERTIES OF ULTRASONIC EXPOSURE

2. Sono-capillary effect

If the liquid in the capillary tube oscillates under the influence of the source of ultrasound, the capillary effect increases dramatically: the height of the liquid column increases several tens of times significantly increases the speed of recovery. Experimentally proven that the fluid is pushing up not by the radiation pressure and the capillary force, but by a standing ultrasonic wave. The ultrasound again and again compress the liquid column and picks it up.

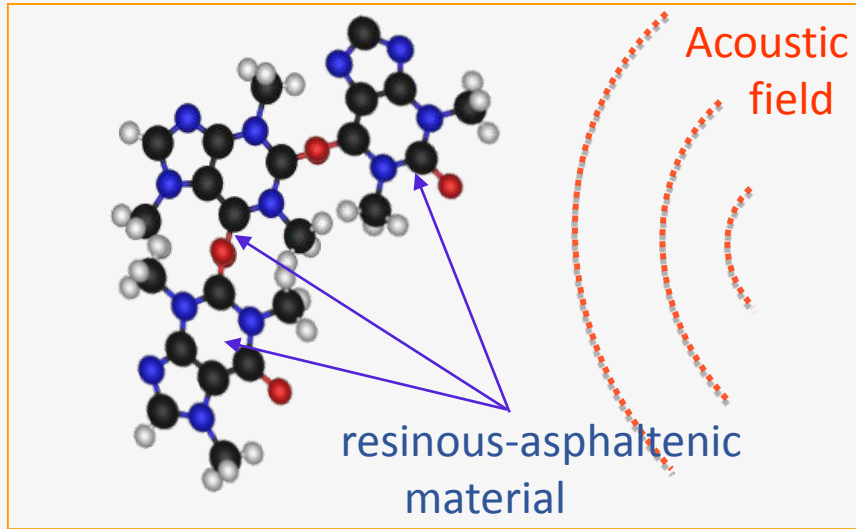
(Discovered by academician E. G. Kononov, 1961)



PHYSICAL PROPERTIES OF ULTRASONIC EXPOSURE

3. Destruction of intermolecular bonds

Before AWS

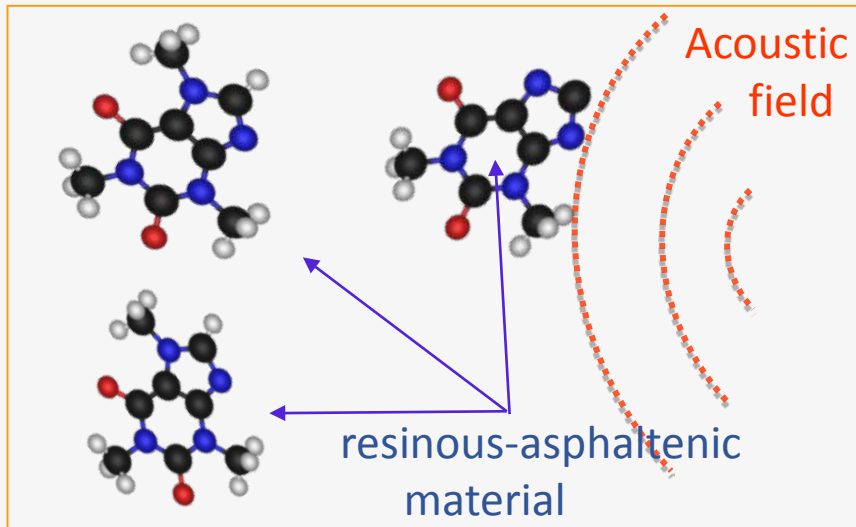


During AWS each molecule of liquid is exposed to time-dependent tension:

$$\sigma(t) = \sigma_0 \sin \omega t$$

If the exposure duration exceeds the time, then there is a rupture of intermolecular bonds

After AWS



$$\tau p = N p / \omega;$$

$$N_p = \frac{\sigma_T}{\sigma_0} - \frac{kT}{\gamma \sigma_0} \ln \left\{ \frac{\sigma_T}{\sigma_0} \right\}$$

Legend:

σ_T – breaking stress for current type of intermolecular bonds,

γ – characteristic for current type of intermolecular bonds,

K – Boltzman constant,

T – temperature.

PHYSICAL PROPERTIES OF ULTRASONIC EXPOSURE SUMMARY

| Physical property | Cavitation | Sono-capillary effect | Destruction of intermolecular bonds |
|---------------------|--|---|---|
| Application | Cleaning of perforation channels | Heavy oil | Cleaning of near-wellbore zone |
| Principle of impact | Detaching crust from boundary of perforation channel | Increase speed of inflow from pores in formation and lead to increase drainage area of the well | Decrease of skin effect by breaking boundary layer on mud filtrate and other foreign particles that lead to easy removal of such particles from formation pores |
| Specific notes | Serious requirements to cement quality | For permanent applications | For temporary treatment during workover operations |

TECHNOLOGY ADVANTAGES

- ✓ COMBINATION WITH EXISTED METHODS OF ENHANCED OIL RECOVERY
- ✓ EFFECTIVE TREATMENT ON WELLS WITH LOW AND ZERO FLOWRATES
- ✓ ABSENCE OF NEGATIVE EFFECT TO ENVIRONMENT AND FORMATION
- ✓ RUSSIAN DEVELOPMENT AND LOCAL MANUFACTURING
- ✓ HIGH PERFORMANCE INDICATOR OF TREATMENTS
- ✓ MAXIMUM GENERATED POWER UP TO 10 KW
- ✓ COMPACT EQUIPMENT AND MOBILE TEAMS
- ✓ UNLIMITED ITERATIONS ON EACH WELL
- ✓ NO DAMAGE TO CEMENT OR CASING
- ✓ A STRONG SCIENTIFIC BACKGROUND
- ✓ HIGH PERFORMANCE ON HEAVY OIL

CONFIRMATION OF EFFICACY

CONFIRMATION OF EFFICIENCY ON LIGHT OIL

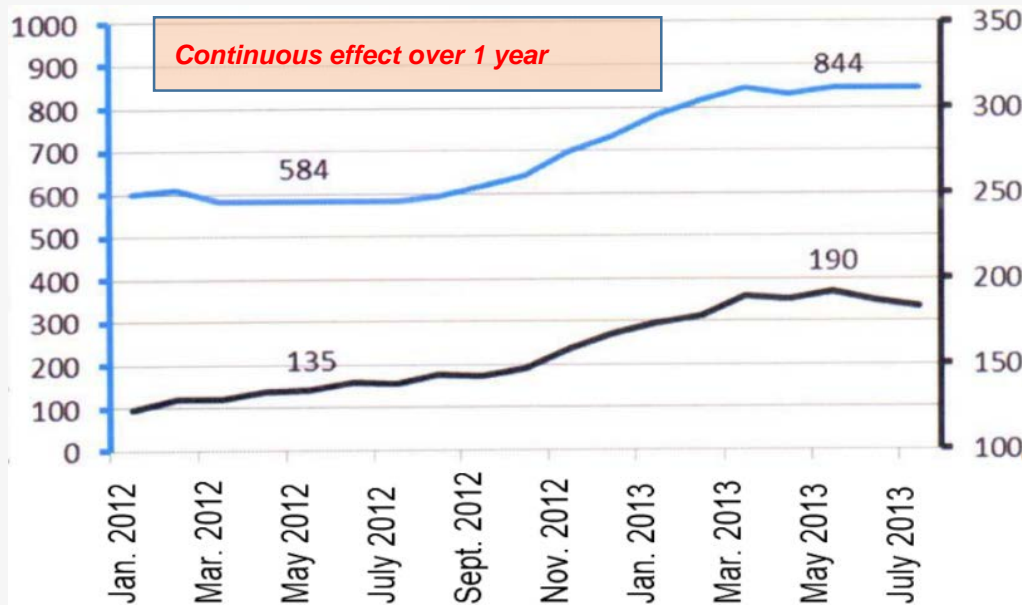
Treatments in 2011-2013

More than 100 wells treated during period from 2011 till 2013 on the territory of Russian Federation:

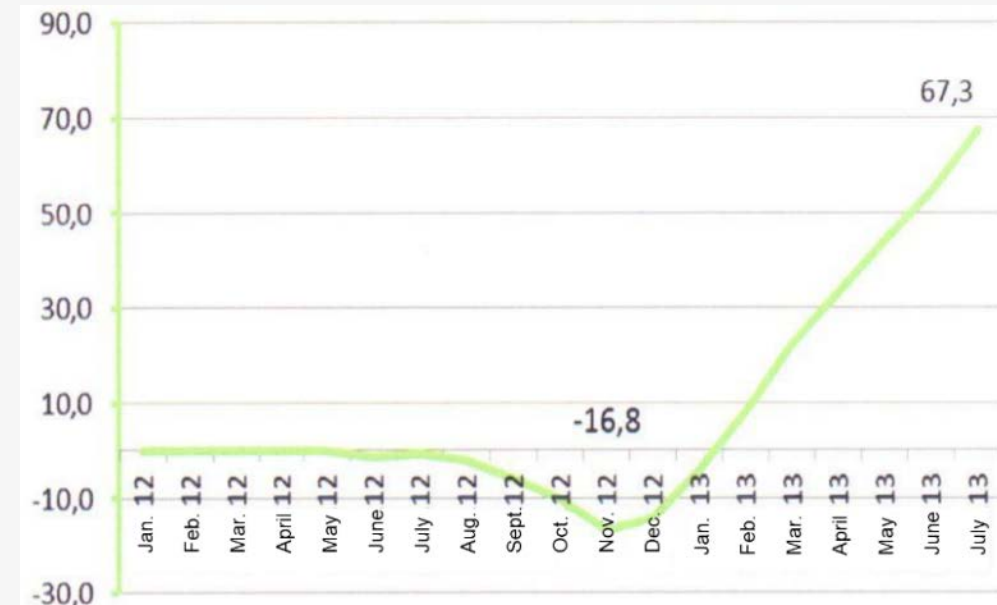
- Average oil production growth – from 4,2 m³/day to 8,4 m³/day (100%)
- Success rate 90%
- Duration of effect from 6 to 24 month

Average results of treatment for one of Clients in Western Siberia:

Liquid and oil flowrate history



Commercial effect, cumulative (mln.rub)



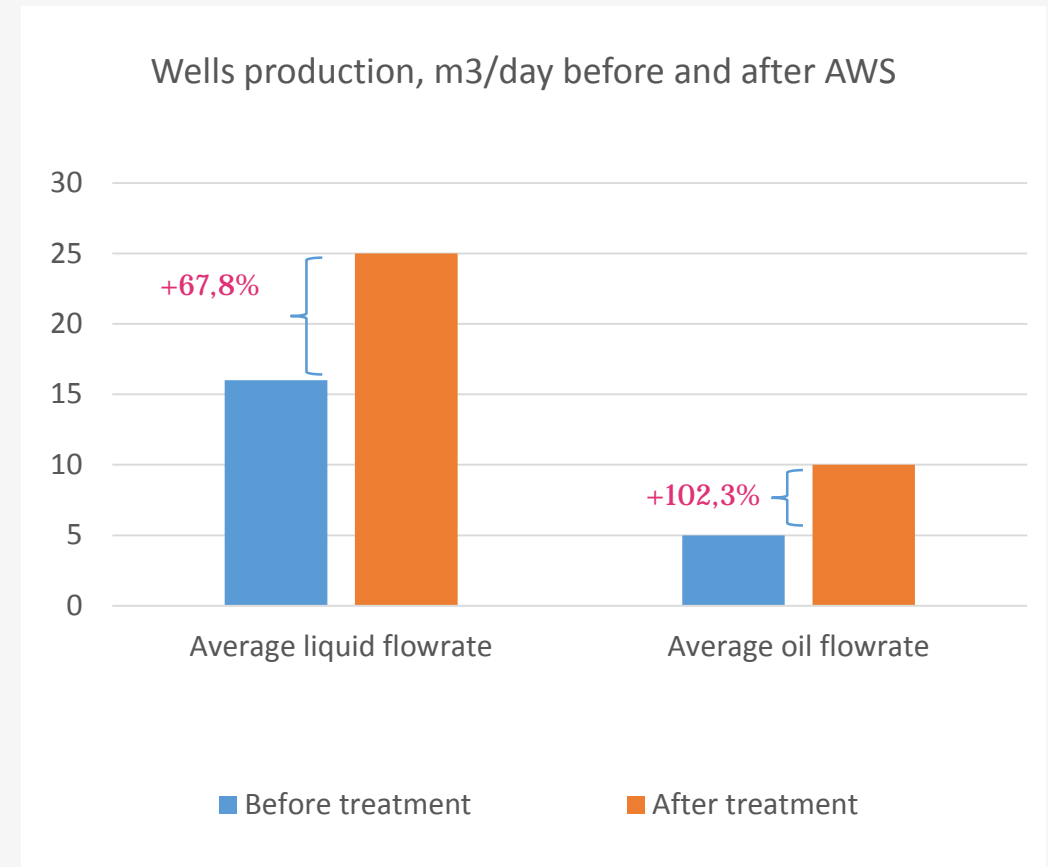
CONFIRMATION OF EFFICIENCY ON LIGHT OIL

Treatments in 2013-2015

More than 100 wells treated during period from 2013 till 2015 on the territory of Russian Federation:

- *Liquid flowrate on wells:*
before treatment 0 – 36 m³/day,
after treatment 4 – 63 m³/day,
- *Average oil production growth 102,3%*
- *Success rate 82%*
- *Duration of effect from 3 to 24 month*

At the same time, wells were not exposed to the damage by acidizing and multiple perforation that helped to preserve the original borehole conditions and the properties of the near-wellbore formation, in this way, unlimited multiplication of ultrasonic treatment and the absence of negative effects is certainly a unique feature of the technology.



CONFIRMATION OF EFFICIENCY ON LIGHT OIL

Treatments in 2012

| № | Client | Oilfield | Well numer | BEFORE TREATMENT | | | | AFTER TREATMENT | | | | EFFECT EVALUATION | | | | |
|-------------------------------|------------------|------------------------|--------------|------------------|---------------|-------|----------------------|-----------------|---------------|-------|----------------------|--------------------|---------------------|---------------------|-------------|----------------------------|
| | | | | Qliq, m3/day | Qoil, ton/day | % w/c | Dynamic liquid level | Qliq, m3/day | Qoil, ton/day | % w/c | Dynamic liquid level | Qliq, m3/day (+/-) | Qoil, ton/day (+/-) | Qoil, difference, % | % w/c (+/-) | Dynamic liquid level (+/-) |
| 1 | Samotlorneftegaz | Samotlorskoe | Confidential | 32,0 | 4,8 | 82,0 | 1463,0 | 40,0 | 8,4 | 75,0 | 1477,1 | 8,0 | 3,6 | 75% | -7,0 | -14,1 |
| 2 | Samotlorneftegaz | Samotlorskoe | Confidential | 18,0 | 2,7 | 82,0 | 1440,0 | 20,0 | 3,0 | 82,0 | 1216,0 | 2,0 | 0,3 | 11% | 0,0 | 224,0 |
| 3 | Samotlorneftegaz | Samotlorskoe | Confidential | 21,0 | 2,5 | 86,0 | 1473,0 | 20,0 | 3,0 | 82,0 | 1321,9 | -1,0 | 0,6 | 24% | -4,0 | 151,1 |
| 4 | Samotlorneftegaz | Samotlorskoe | Confidential | 35,0 | 4,4 | 85,0 | 1307,0 | 60,0 | 26,2 | 48,0 | 1428,7 | 25,0 | 21,8 | 495% | -37,0 | -121,7 |
| 5 | Samotlorneftegaz | Samotlorskoe | Confidential | 14,0 | 4,4 | 63,0 | 1370,0 | 50,0 | 11,8 | 72,0 | 1324,0 | 36,0 | 7,4 | 168% | 9,0 | 46,0 |
| 6 | Samotlorneftegaz | Samotlorskoe | Confidential | 13,0 | 6,6 | 40,0 | 1947,0 | 23,0 | 7,3 | 62,0 | 1645,2 | 10,0 | 0,8 | 12% | 22,0 | 301,8 |
| 7 | Samotlorneftegaz | Samotlorskoe | Confidential | 24,0 | 2,6 | 87,0 | 1025,0 | 46,0 | 12,4 | 68,0 | 1293,1 | 22,0 | 9,7 | 373% | -19,0 | -268,1 |
| 8 | Samotlorneftegaz | Samotlorskoe | Confidential | 7,0 | 4,6 | 22,0 | 1604,0 | 22,0 | 13,9 | 25,0 | 1529,0 | 15,0 | 9,3 | 202% | 3,0 | 75,0 |
| 9 | Samotlorneftegaz | Samotlorskoe | Confidential | 12,0 | 2,2 | 78,0 | 1643,0 | 12,0 | 2,2 | 78,0 | 1603,5 | 0,0 | 0,0 | 0% | 0,0 | 39,5 |
| 10 | Samotlorneftegaz | Samotlorskoe | Confidential | 26,0 | 2,2 | 90,0 | 1694,0 | 22,0 | 3,7 | 80,0 | 1345,1 | -4,0 | 1,5 | 68% | -10,0 | 348,9 |
| 11 | Samotlorneftegaz | Samotlorskoe | Confidential | 25,0 | 6,1 | 71,0 | 990,0 | 49,0 | 10,3 | 75,0 | 1188,2 | 24,0 | 4,2 | 69% | 4,0 | -198,2 |
| 12 | Samotlorneftegaz | Samotlorskoe | Confidential | 8,0 | 5,2 | 22,0 | 1277,0 | 10,0 | 5,4 | 36,0 | 1115,5 | 2,0 | 0,1 | 2% | 14,0 | 161,5 |
| 13 | Samotlorneftegaz | Samotlorskoe | Confidential | 17,0 | 2,9 | 80,0 | 1627,0 | 22,0 | 2,8 | 85,0 | 1596,4 | 5,0 | -0,1 | -3% | 5,0 | 30,6 |
| 14 | Samotlorneftegaz | Samotlorskoe | Confidential | 16,0 | 2,7 | 80,0 | 1353,0 | 25,0 | 5,5 | 74,0 | 1462,0 | 9,0 | 2,8 | 104% | -6,0 | -109,0 |
| 15 | Samotlorneftegaz | Samotlorskoe | Confidential | 22,0 | 4,4 | 76,0 | 1355,0 | 36,0 | 7,6 | 75,0 | 1288,4 | 14,0 | 3,1 | 70% | -1,0 | 66,6 |
| 16 | Samotlorneftegaz | Samotlorskoe | Confidential | 18,7 | 2,0 | 87,5 | 1656,0 | 18,0 | 3,0 | 80,0 | 1426,5 | -0,7 | 1,1 | 55% | -7,5 | 229,5 |
| 17 | Samotlorneftegaz | Samotlorskoe | Confidential | 37,0 | 3,4 | 89,1 | 1249,0 | 57,0 | 4,8 | 90,0 | 1199,1 | 20,0 | 1,4 | 41% | 0,9 | 49,9 |
| 18 | Samotlorneftegaz | Samotlorskoe | Confidential | 13,0 | 3,5 | 68,3 | 1584,5 | 15,0 | 7,6 | 40,0 | 1553,9 | 2,0 | 4,1 | 117% | -28,3 | 30,6 |
| 19 | Samotlorneftegaz | Samotlorskoe | Confidential | 30,0 | 5,0 | 80,0 | 895,0 | 74,0 | 9,9 | 84,0 | 1328,6 | 44,0 | 4,9 | 98% | 4,0 | -433,6 |
| 20 | Samotlorneftegaz | Samotlorskoe | Confidential | 17,0 | 2,4 | 83,0 | 1229,0 | 18,0 | 1,5 | 90,0 | 1570,2 | 1,0 | -0,9 | -38% | 7,0 | -341,2 |
| 21 | Samotlorneftegaz | Samotlorskoe | Confidential | 36,0 | 3,0 | 90,0 | 1295,0 | 57,0 | 15,8 | 67,0 | 1367,5 | 21,0 | 12,8 | 427% | -23,0 | -72,5 |
| 22 | Samotlorneftegaz | Samotlorskoe | Confidential | 33,0 | 4,2 | 85,0 | 877,0 | 50,0 | 7,6 | 82,0 | 1329,2 | 17,0 | 3,4 | 81% | -3,0 | -452,2 |
| 23 | Samotlorneftegaz | Samotlorskoe | Confidential | 17,0 | 2,6 | 82,0 | 1252,0 | 33,0 | 5,0 | 82,0 | 1309,2 | 16,0 | 2,4 | 92% | 0,0 | -57,2 |
| 24 | Samotlorneftegaz | Samotlorskoe | Confidential | 9,0 | 2,0 | 74,0 | 1351,0 | 11,0 | 2,8 | 70,0 | 1580,9 | 2,0 | 0,8 | 40% | -4,0 | -229,9 |
| 25 | Samotlorneftegaz | Samotlorskoe | Confidential | 10,0 | 2,1 | 75,0 | 1648,0 | 15,0 | 6,2 | 51,0 | 1604,2 | 5,0 | 4,1 | 195% | -24,0 | 43,8 |
| 26 | Samotlorneftegaz | Samotlorskoe | Confidential | 18,0 | 2,3 | 85,0 | 1550,0 | 18,0 | 2,3 | 85,0 | 1573,4 | 0,0 | 0,0 | 0% | 0,0 | -23,4 |
| 27 | Samotlorneftegaz | Samotlorskoe | Confidential | 32,0 | 6,7 | 75,0 | 1236,0 | 48,0 | 12,1 | 70,0 | 1376,5 | 16,0 | 5,4 | 81% | -5,0 | -140,5 |
| 28 | Samotlorneftegaz | Samotlorskoe | Confidential | 8,0 | 6,4 | 5,0 | 1858,0 | 6,0 | 4,9 | 3,0 | 1556,7 | -2,0 | -1,5 | -23% | -2,0 | 301,3 |
| 29 | Samotlorneftegaz | Samotlorskoe | Confidential | 32,0 | 9,1 | 66,0 | 1733,0 | 52,0 | 16,6 | 62,0 | 1587,3 | 20,0 | 7,5 | 82% | -4,0 | 145,7 |
| 30 | Samotlorneftegaz | Samotlorskoe | Confidential | 20,0 | 3,4 | 80,0 | 1772,0 | 33,0 | 6,9 | 75,0 | 1440,1 | 13,0 | 3,6 | 106% | -5,0 | 331,9 |
| AVERAGE for Samotlorneftegaz | | | | 20,7 | 3,9 | 72,3 | 1425,1 | 32,1 | 7,7 | 68,3 | 1421,2 | 11,4 (+ 55%) | 3,8 | 98% | -4,0 | 3,9 |
| 31 | Samaraneftegaz | Vetlyanskoe | Confidential | 36,0 | 10,0 | 66,0 | 1310,0 | 48,0 | 13,0 | 67,7 | 1690,0 | 12,0 | 3,0 | 30% | 1,7 | -380,0 |
| 32 | Samaraneftegaz | Sofyinsko-Dzerzhinskoe | Confidential | 22,0 | 6,0 | 68,8 | 1652,0 | 37,0 | 10,0 | 67,0 | 1729,0 | 15,0 | 4,0 | 67% | -1,8 | -77,0 |
| 33 | Samaraneftegaz | Solotskoe | Confidential | 48,0 | 14,0 | 65,0 | 1711,0 | 75,0 | 39,5 | 38,0 | 1207,0 | 27,0 | 25,5 | 182% | -27,0 | 504,0 |
| AVERAGE for Samaraneftegaz | | | | 35,3 | 10,0 | 66,6 | 1557,7 | 53,3 | 20,8 | 57,6 | 1542,0 | 18,0 (+ 51%) | 10,8 | 108% | -9,0 | 15,7 |
| TOTAL AVERAGE for 2012 | | | | 22,0 | 4,4 | 71,8 | 1436,8 | 33,9 | 8,8 | 67,3 | 1431,9 | 12,0 (+55%) | 4,4 | 100% | -4,5 | 4,9 |

CONFIRMATION OF EFFICIENCY ON HEAVY AND VISCOUS OIL

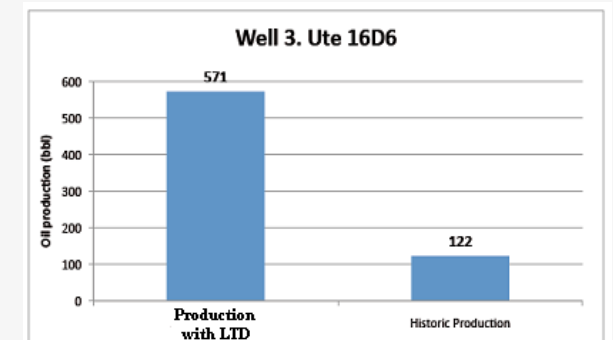
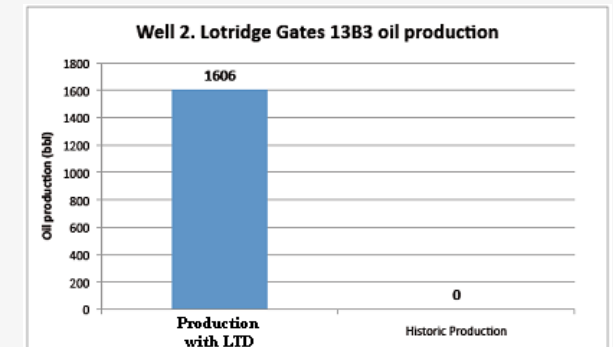
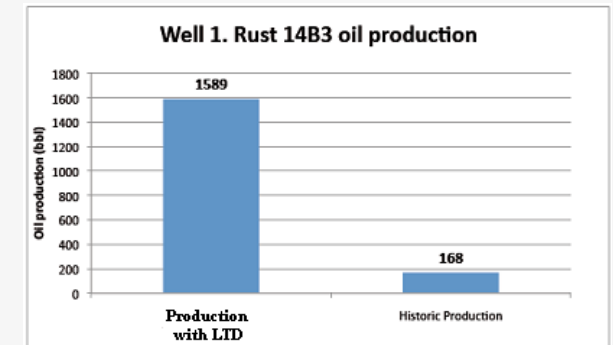
- Continuous AWS has been tested at low producing wells of Green River Formation, USA in 2008.
- This field was selected for pilot tests because represent traditional hard-to-recover oil deposits

By results of pilot test of technology of ultrasonic treatment, US Department of Energy made following conclusion:

«... If the (AWS) technology becomes widely adapted in the United States and throughout the oil and gas industry, there may be a large increase in production of hydrocarbon fluids. The resulting increase in domestic production could decrease the dependency of the United States on foreign oil» ©



From 2014 this type of services provided by Joint Venture with Nanocentre of Tatarstan Republic (ROSNANO entity) – LLC “SONOTECH”



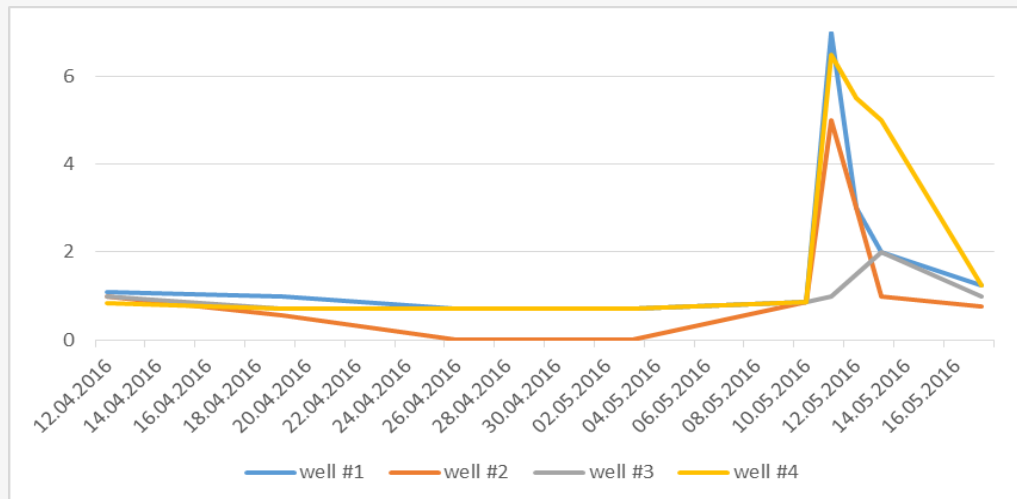
CONFIRMATION OF EFFICIENCY ON HEAVY AND VISCOUS OIL

Outstanding results on extra-low rates heavy oil wells in Canada in 2016

| Date | 12.04.2016 | 19.04.2016 | 26.04.2016 | 03.05.2016 | 10.05.2016 | 11.05.2016 | 12.05.2016 | 13.05.2016 | 17.05.2016 |
|--|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Average daily flowrate, bbl/day | | | | | | | | | |
| Well #1 | 1,08 | 1,00 | 0,71 | 0,71 | 0,86 | 7,00 | 3,00 | 2,00 | 1,25 |
| Well #2 | 1,00 | 0,57 | 0,00 | 0,00 | 0,86 | 5,00 | 3,00 | 1,00 | 0,75 |
| Well #3 | 1,00 | 0,71 | 0,71 | 0,71 | 0,86 | 1,00 | 1,50 | 2,00 | 1,00 |
| Well #4 | 0,83 | 0,71 | 0,71 | 0,71 | 0,86 | 6,50 | 5,50 | 5,00 | 1,25 |

--> <-- AWS treatment

| | Relative productivity growth | | | | | |
|---------|------------------------------|------|------|------|------|------|
| | Days after treatment -> | 0 | 1 | 2 | 3 | 7 |
| Well #1 | | 100% | 817% | 350% | 233% | 146% |
| Well #2 | | 100% | 583% | 350% | 117% | 88% |
| Well #3 | | 100% | 117% | 175% | 233% | 117% |
| Well #4 | | 100% | 758% | 642% | 583% | 146% |



Instant productivity growth > **800%**
Effect duration – up to **7 days**

Single stimulation proved that installation of oscillators for continuous operations will allow to keep productivity rate at level of 700-800% from initial and will require to power up oscillators just for 30 minutes daily

Project status: ongoing discussions on Phase 2 details – introduction of AWS equipment for permanent installation

CONFIRMATION OF EFFICIENCY ON HEAVY AND VISCOUS OIL

▪ SC «TATEX», Republic of Tatarstan, Russian Federation

Treatment of 2 wells of Demkinskoe field in 2015:

| Description | WELL 1 | WELL 2 |
|-----------------------------|--------|--------|
| Instant oil flowrate growth | + 15% | + 30% |
| Effect duration | 3 days | 3 days |

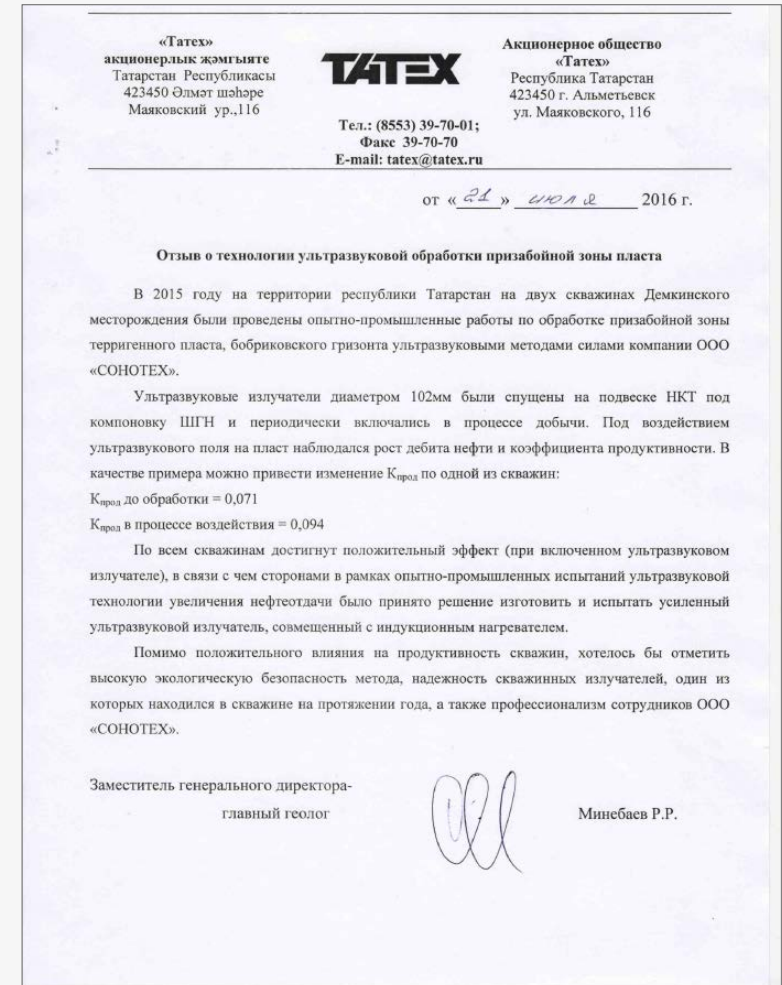
Trial job proved technology efficiency in the formation conditions

On Well #1 equipment was removed after the treatment

On Well #2 equipment kept in the well for the continuous monitoring for 1 year

Project status: ongoing selection of 3-5 wells for the treatment with thermo-acoustic oscillator in 2017.

Recognition letter:

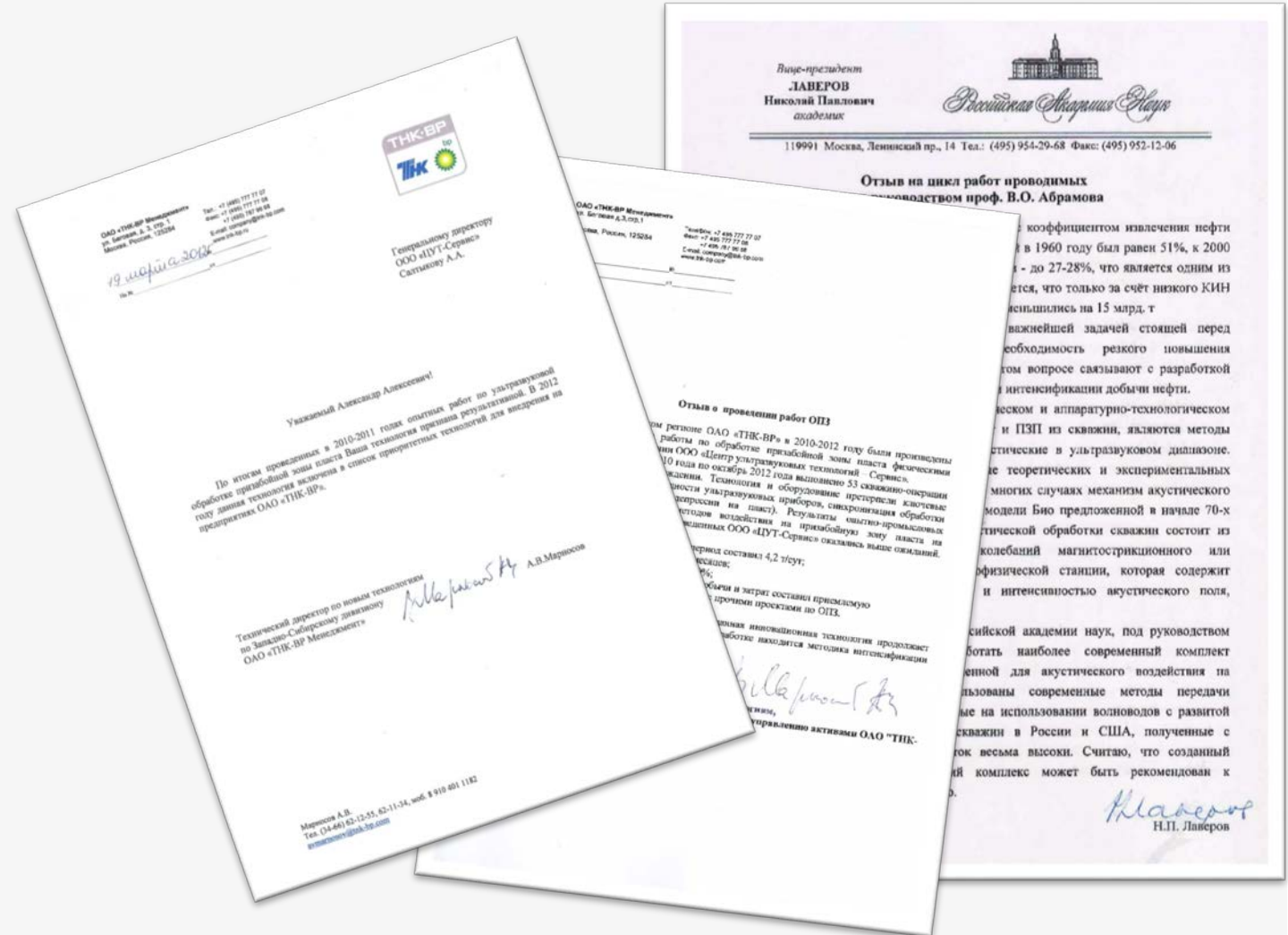


CONFIRMATION OF EFFICIENCY

Recognition letters

Technology went through all levels of field trials from 2010 until 2012 and was added to the list of priority technologies to deployment in TNK-BP by HQ Management.

From 2012 technology fully commercialized in Russian Federation



QUESTIONS