

NEFTEMER

Multiphase metering of heavy oil

by

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Neftemer - overview

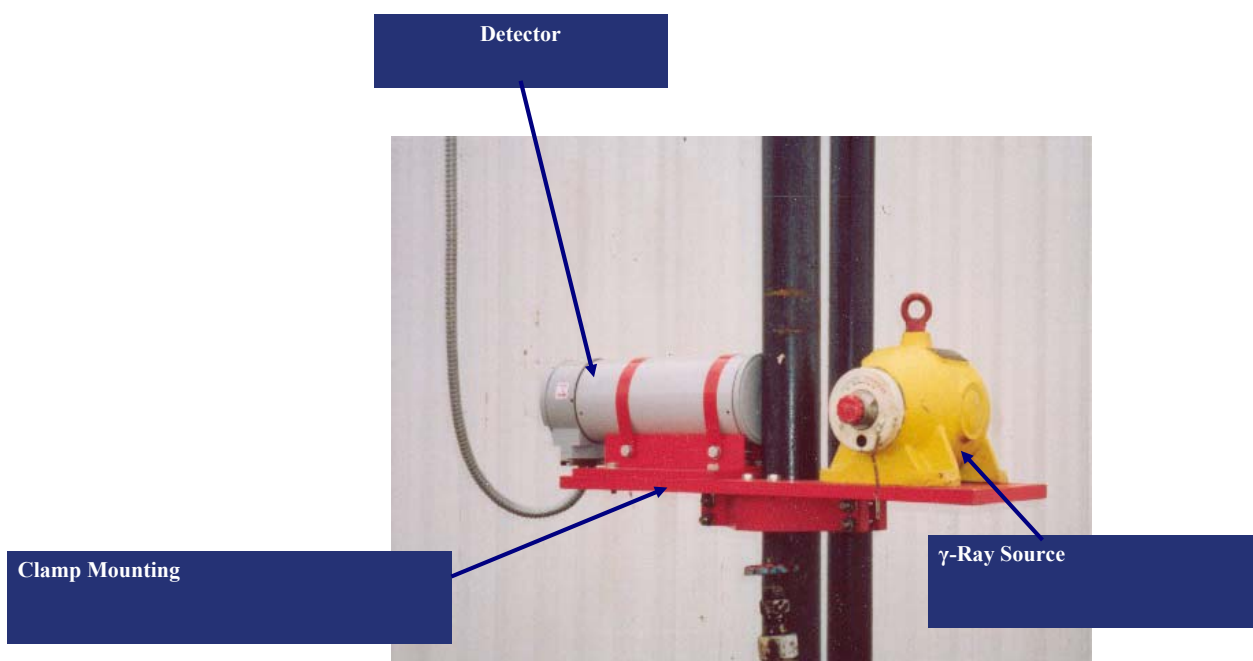
- **Objective of presentation**
 - A different approach to multiphase metering
 - Different applications
 - Heavy oil, relatively low producers
 - Is field verification practical?
- **Outline of Neftemer development**
- **Field and laboratory test results**
- **GOST standard on hydrocarbons from wells**
- **Conclusions**

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- **Multiphase metering development**
 - Began in late 1970s /early 1980s
 - Based on data from laboratory test loops
 - Aim was low cost meter per well
 - Expectation of dramatic savings
 - In field development costs, from simpler equipment
 - In operational costs, from improved information
- **Expectation partly realised**
 - Multiphase meters better than test separators
 - About 1600 meters installed in West
 - Many as replacement for test separator
 - Still expensive to buy and install

- **Late 1970s V. Kratirov at Space Institute**
 - γ -ray meter for steam/water flows in nuclear reactor
 - Based on interpreting fast fluctuations in density
 - Could be adapted for oil industry
- **Development based on fieldwork**
 - Data from wells gathered over several years
 - How best to deploy detectors
 - Practical verification techniques
 - Separator tank on weigh bridge (gas not important)
 - Mass units the automatic choice
 - Emphasis on heavy oil
 - By 2007 several hundred units installed

- **First contacts outside Russia about 1996**
 - Paper presented at 1997 “Norflow” seminar
 - Interest shown, but R&D budgets had been cut
- **Consortium to market Neftemer met in 2003**
 - Tests to be done at Cranfield University
- **Testing began 2005**
- **Approval work proceeding**
 - International electrical safety certification
 - Approval for radioactive source holder
- **Target market**
 - Heavy oil wells similar to those in Russia



Neftemer installations



Single meter on beam-pump well

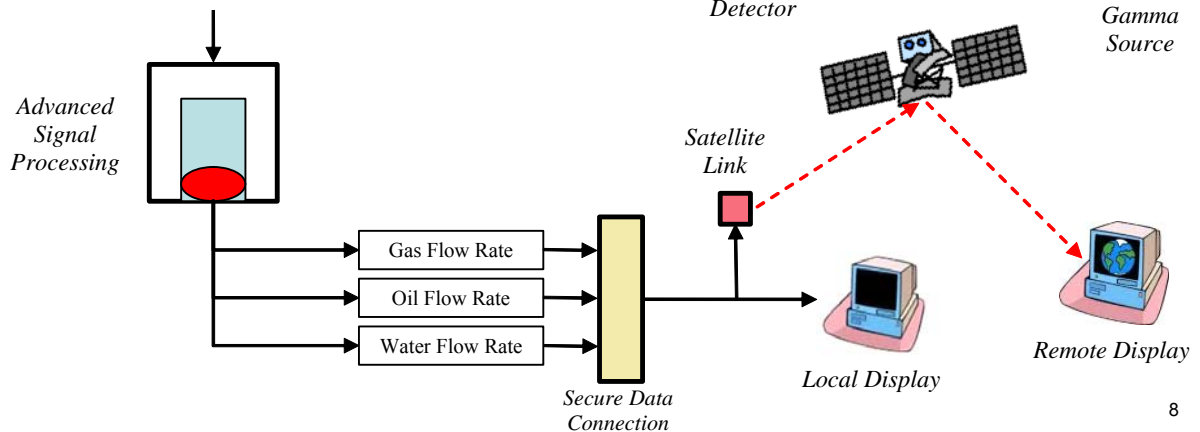
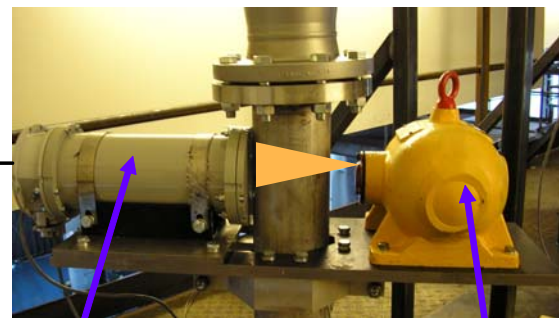
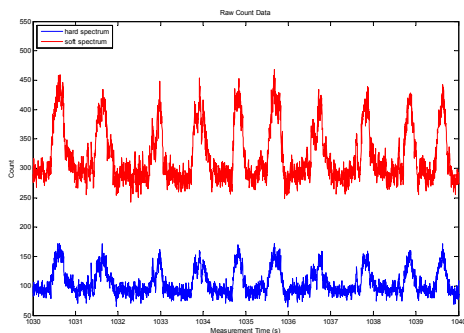


Multiple meters (up to ten) surrounding a single multi-window source



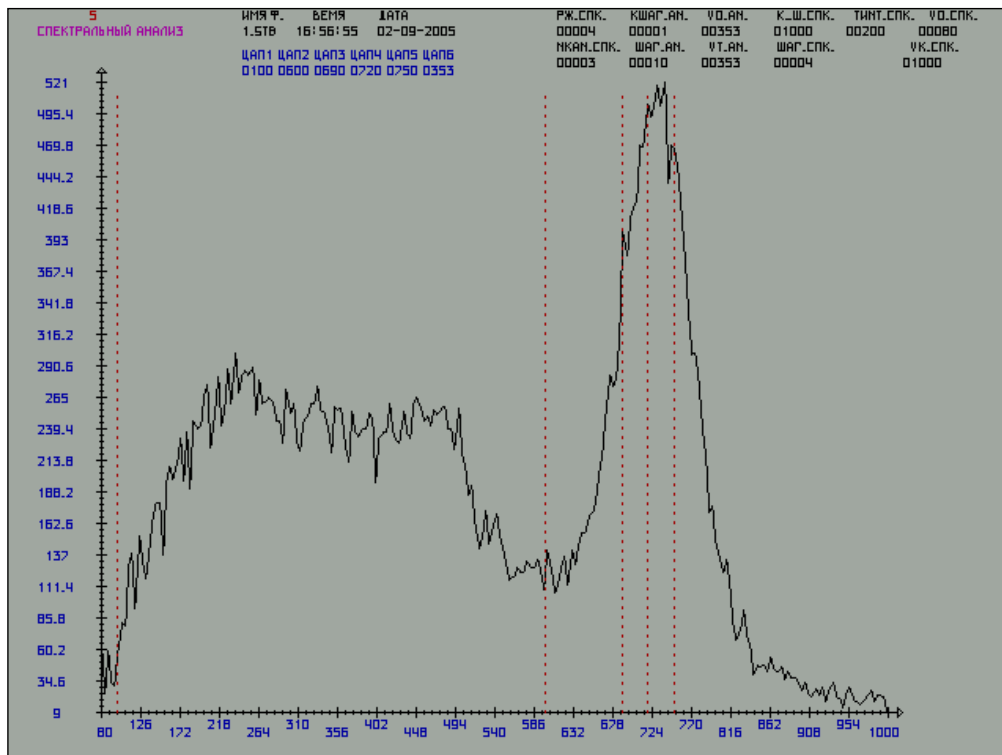
Prototype in field installation

Neftemer operation



Detected Spectrum

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How it works - Basics

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- **Calculation cycle runs every 2 seconds**
 - Effectively flow is divided into 2-second sections
 - liquid mass flowrate
 - gas volume flowrate
 - (mass) watercut of liquid
 - Integrate to get totals for liquid, oil, water, gas
- **Neftemer depends on density fluctuations**
 - In practice for much of the time there aren't any
 - Hold last good calculated values, update when data allows
- **Gas bubbles give liquid and gas velocities**
 - Bubble sizes can be inferred from amplitude and width of density fluctuations

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- **Bubbles below critical size are entrained in liquid**
 - Give liquid velocity
- **Average velocity of all bubbles**
 - Gives gas velocity
- **From R&D programme, spectral patterns found**
 - For both liquid and gas
 - Frequency of appearance strongly related to velocity
- **High scan rate of 250 Hz**
 - Allows velocities to be calculated over wide range

- **Single phase γ -absorptions**
 - Input to system during calibration
- **Phase fractions determined using**
 - First, overall γ -density
 - Second, standard dual-energy equations
 - Absorptions at two pre-defined energy levels in detected spectrum
 - Third, overall shape of detected spectrum
 - Shape related to oil, water and gas fractions
 - For liquid, shape related to carbon/hydrogen ratio
- **Phase fractions and liquid and gas velocities**
 - Combined with area gives phase flowrates

- **Basis of method**

- Sophisticated mathematical analysis
- Sophisticated statistical signal processing
- Yields accurate measurements

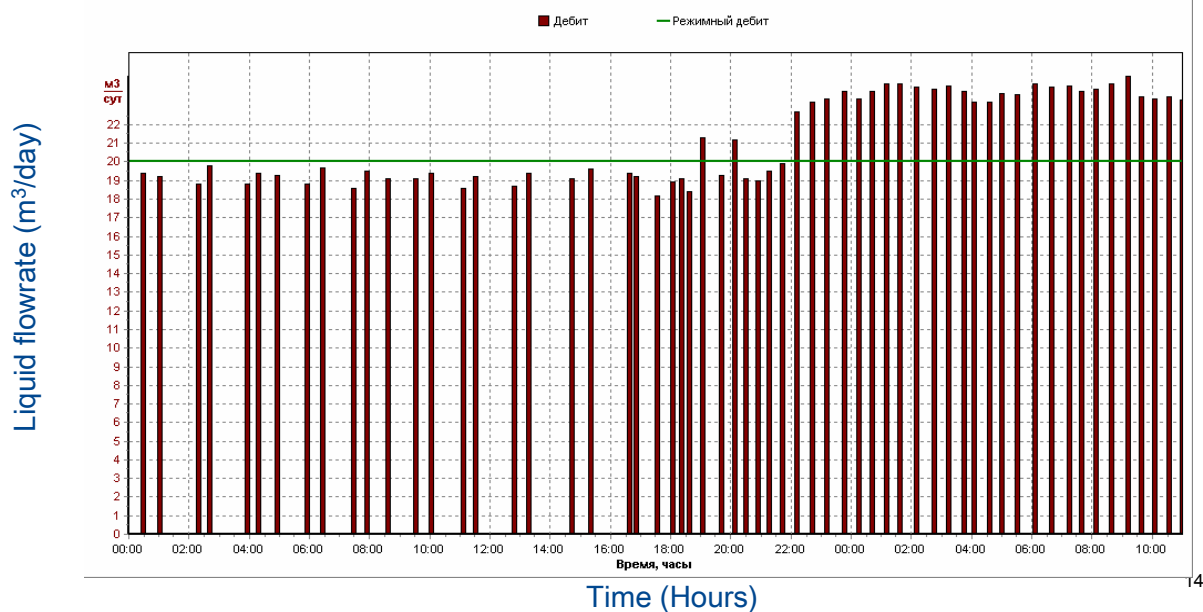
- **In practice**

- Simplifications
 - To allow Neftemer to operate in real time
- Tuning
 - Required for a new application

Production increase on increasing speed of pump

Скважина, оснащенная установкой ЭВНТ 25×1500 (ВВД)

Изменение показаний прибора Нефтемер (оперативные значения массового расхода жидкости) после увеличения оборотов ЭВНТ с 1000 до 1200 об/мин.

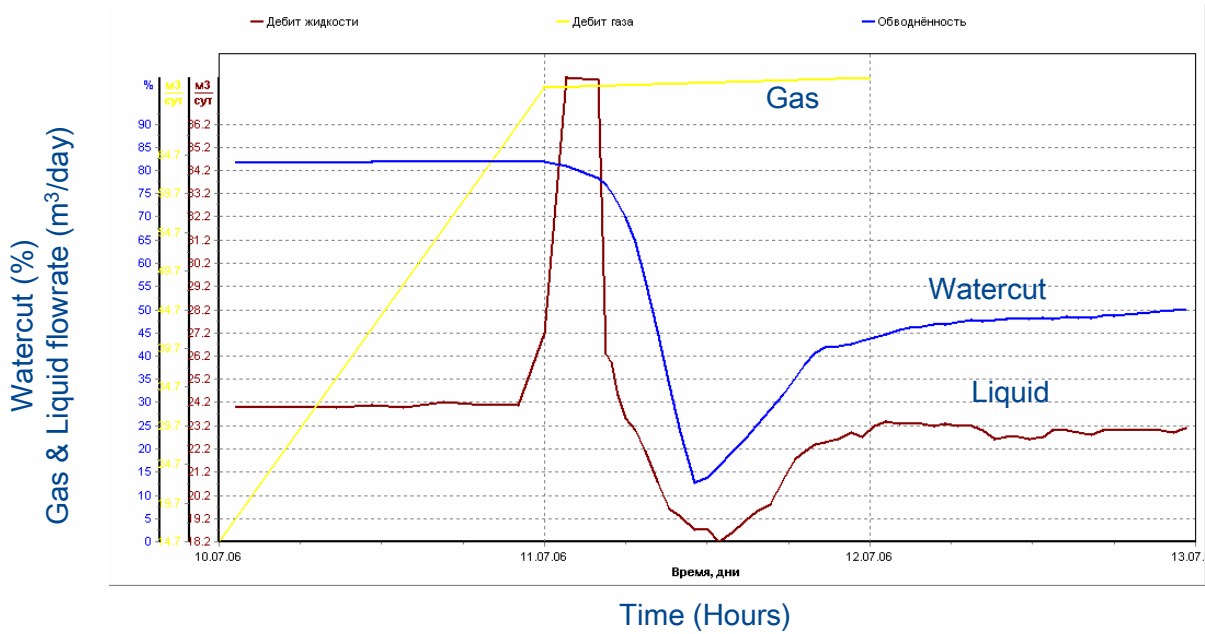


Settling of well production over three days from opening up

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Скважина, оснащенная установкой ЭВНТ 25×1500

Показания прибора Нефтемер (оперативные значения массового расхода жидкости, объемного расхода газа и обводненности) при выходе скважины на режим после освоения.

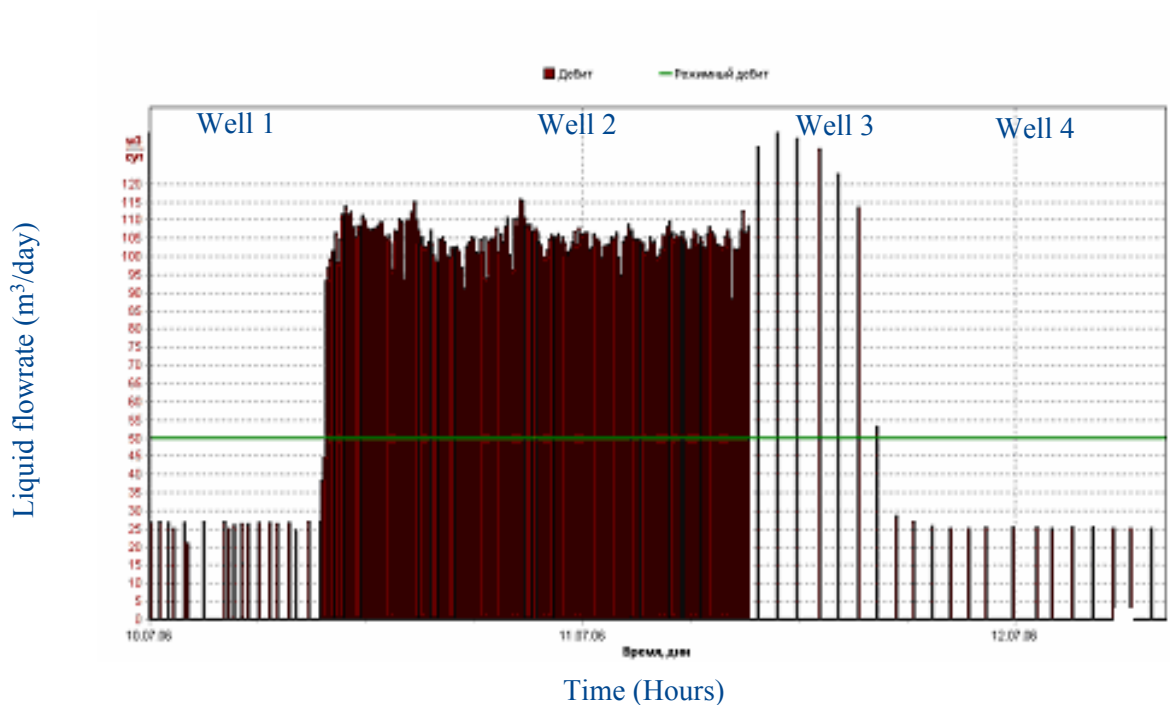


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Different wells routed in turn to same measurement section

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Показания прибора Нефтемер (массовый расход жидкости) при направлении в один и тот же измерительный участок по очереди потоков продукции только одной из скважин с разной производительностью.

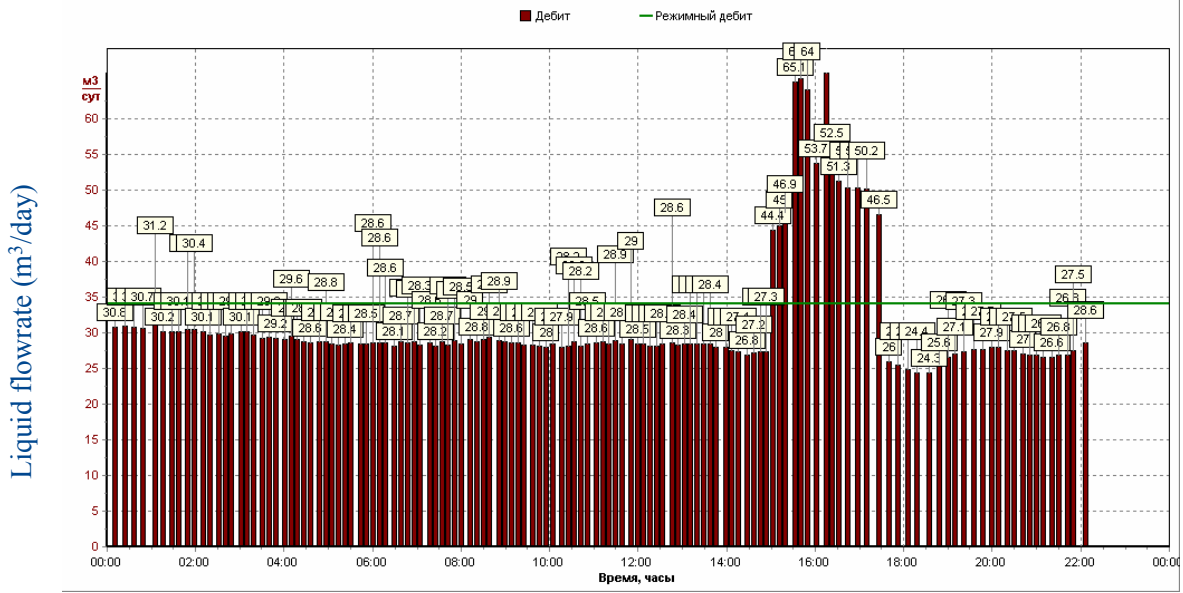


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Increased production from injection of light oil into well

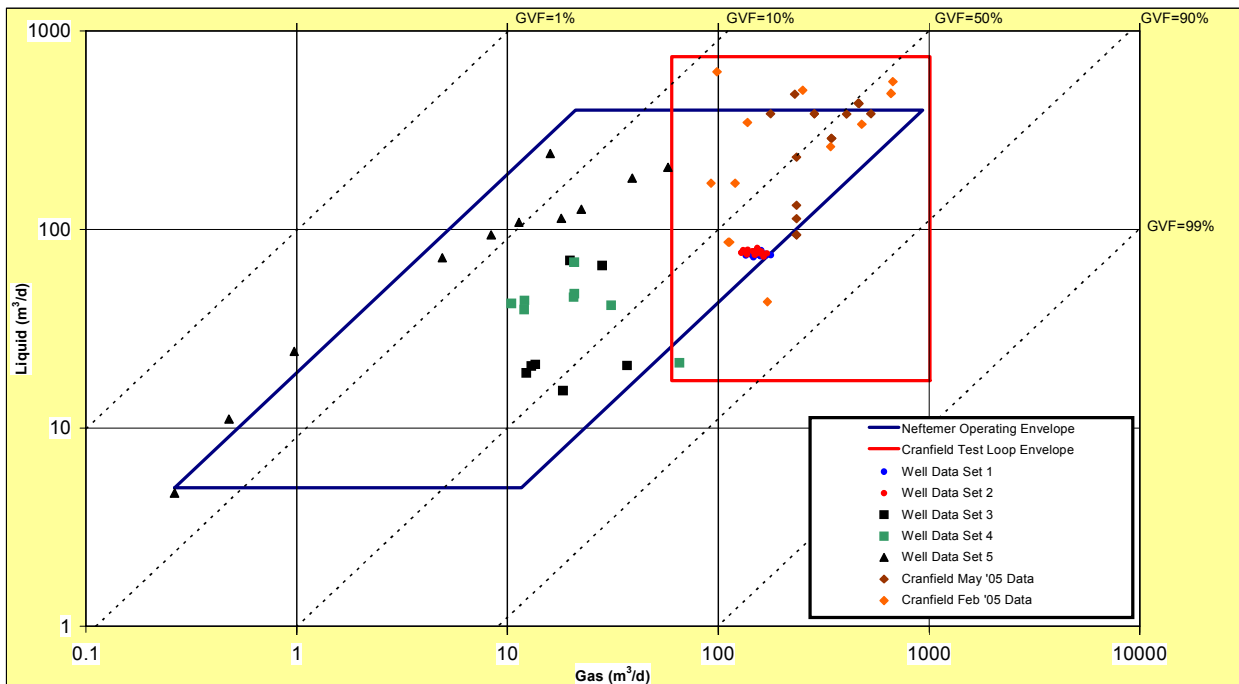
Скважина, оснащенная установкой НН2Б-70-30

Реакция прибора Нефтемер (оперативные значения массового расхода жидкости) на промывку (прокачку) скважины легкой нефтью агрегатом АДП.



Time (Hours)

Operating envelope



- **Earlier field tests (1995/96, 1998, 2001)**
 - Show improvements and moves to heavy oil
 - Discussed in NSFMW 2006 paper
- **July 2006 tests**
 - Comparative testing on heavy oil wells not possible
 - Separator on weighbridge designed but not ordered
 - Discrepancies between
 - Neftemer indications and operator expectations
 - Great interest in “demonstration” test
 - At gathering station with good oil and water metering
 - Using light oil (density 820 kg/m³)

“Demonstration” test

- **At gathering station**
 - Crude oil from three fields separated and metered
 - Oil using Smiths PD meters
 - Water using Halliburton turbine meters
 - Gas not metered accurately
- **Single Neftemers installed**
 - On three 3-phase pipelines from fields
 - One 325 mm pipe, two 219 mm pipes
 - 325 mm pipe conveyed >99% of total production
- **Plan - set up equipment, then seal for one month**
 - Independent comparison of daily production totals
- **Data shown**
 - From 11-day preliminary period of test

Results of 2006 test

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Date	Error (only for 325 mm pipeline)			Error (all 3 pipelines)			
	Relative error mass liquid, %	Relative error mass water, %	Relative error mass oil, %	Relative error mass liquid, %	Relative error mass water, %	Relative error mass oil, %	Abs. error Mass Watercut %
06/07/06	-0.6	-3.2	5.5	0.1	-2.2	5.6	-1.6
07/07/06	-1.9	-4.7	5.4	-1.2	-3.7	5.5	-1.9
08/07/06	-0.1	-2.3	6.1	0.7	-1.4	6.3	-1.5
09/07/06	-1.7	-1.8	-1.4	-0.9	-0.8	-1.3	0.1
10/07/06	0.5	1.3	-1.4	1.3	2.3	-1.2	0.7
11/07/06	1.3	3.7	-5.0	2.0	4.7	-4.8	1.9
12/07/06	-1.8	-1.5	-2.6	-1.0	-0.5	-2.5	0.4
14/07/06	-0.3	2.0	-5.9	0.5	3.0	-5.7	1.8
15/07/06	1.0	5.2	-9.1	1.7	6.1	-9.0	3.1
16/07/06	-2.2	-4.4	3.6	-1.5	-3.4	3.7	-1.5
17/07/06	-1.1	-3.7	5.9	-0.4	-2.8	6.1	-1.8
Average	-0.63	-0.84	0.10	0.11	0.12	0.25	-0.02
2 x Std. Dev.	2.43	6.76	10.90	2.44	6.79	10.90	3.49

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Observations on test - 1

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- **Low average errors in daily production totals**
 - Liquid 0.11%, water 0.12%, oil 0.25%
 - Indicates daily variation was mostly random
- **Average errors for pipe 325 (e.g. liquid -0.63%)**
 - Reflect introduction of systematic error
 - Smaller pipelines transporting mostly water
 - Neftemer could see small changes in multiphase flow
- **Results indicate 2.4% liquid and 3.5% watercut**
 - Variation in daily production over test <6%
 - Can consider test as 11 repeats
 - 2 x standard deviation gives indication of uncertainties
 - Slijkerman et al. 1995 call for 5-10% liquid, 2% watercut

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Observations on test - 2

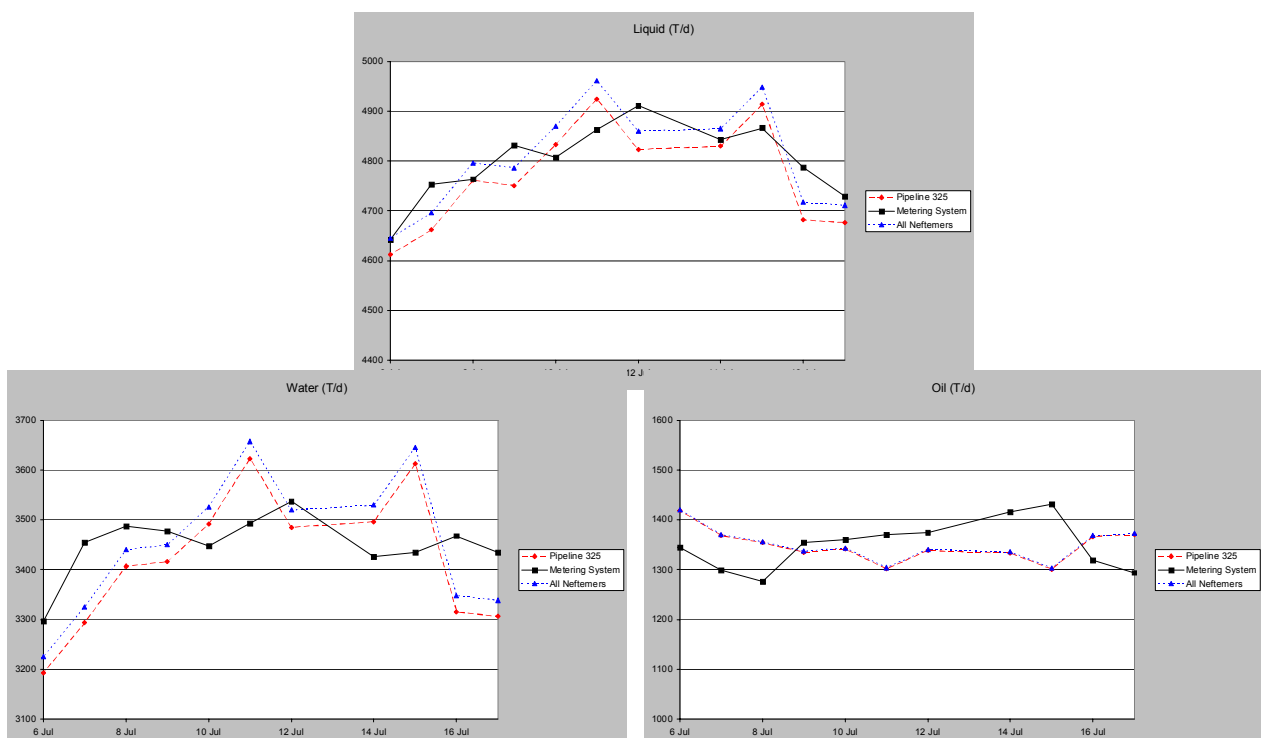
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- **Reconsider variation in liquid production**
 - Indicated uncertainty 2.4%, less than variation of 6%
 - Expect Neftemer to track this variation, and it does
- **Variation in water and oil production**
 - Indicated uncertainties slightly less than variation
 - Water : 6.8% uncertainty, 7.3% variation
 - Oil : 10.9% uncertainty, 12.2% variation
 - Do not expect to see clear tracking
- **Neftemers on smaller pipelines**
 - Measuring very low flowrates
 - Plots indicate that they give reasonable data
 - Key to this is the high scan rate of the detector

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Comparison of daily totals

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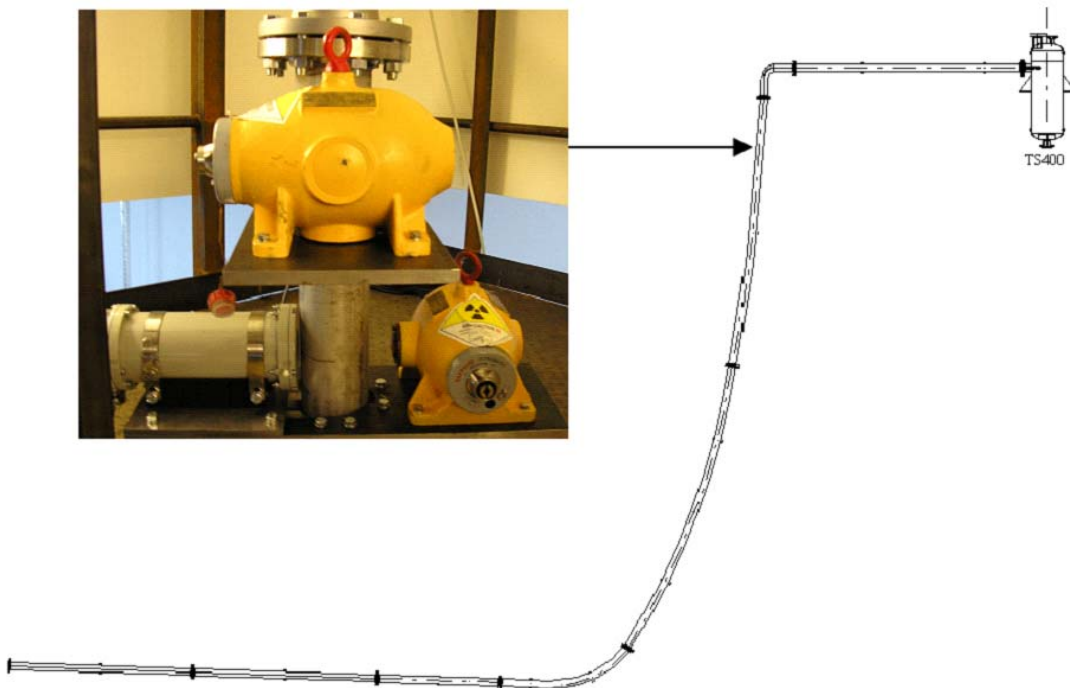
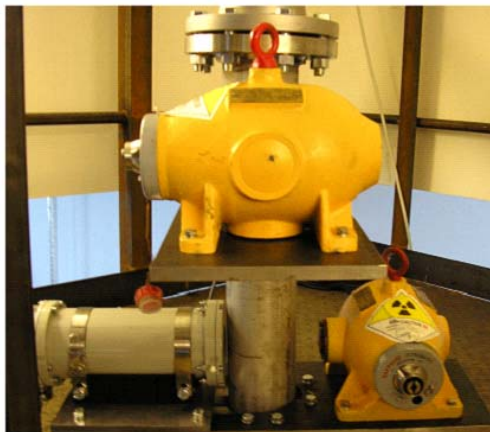
- **Flow conditions not stable in “formal” period**
 - Operator has not reported the data
- **Fluids at test location**
 - not representative of field where Neftemer is used
- **Visit by senior management**
 - Agreed Neftemer essential for field management
 - Measurement of heavy oil
 - Monitoring for problems with wells
- **Decision to deploy more Neftemers, subject to**
 - Evaluation to new GOST standard R 8.615-2005
 - Hydrocarbons from individual wells
 - Measurement of oil from “licensed area”

- **Using Cranfield University multiphase facility**
- **Test programme based on Multiflow 2 JIP**
 - To give direct comparison with other meters
 - Subset of test points
- **Significant differences from field conditions**
 - Stainless steel versus carbon steel pipe
 - Light lubricating oil versus heavy oil
- **Target was to get agreement with test facility**
 - $\pm 10\%$ relative for gas and liquid
 - Follow trend for watercut

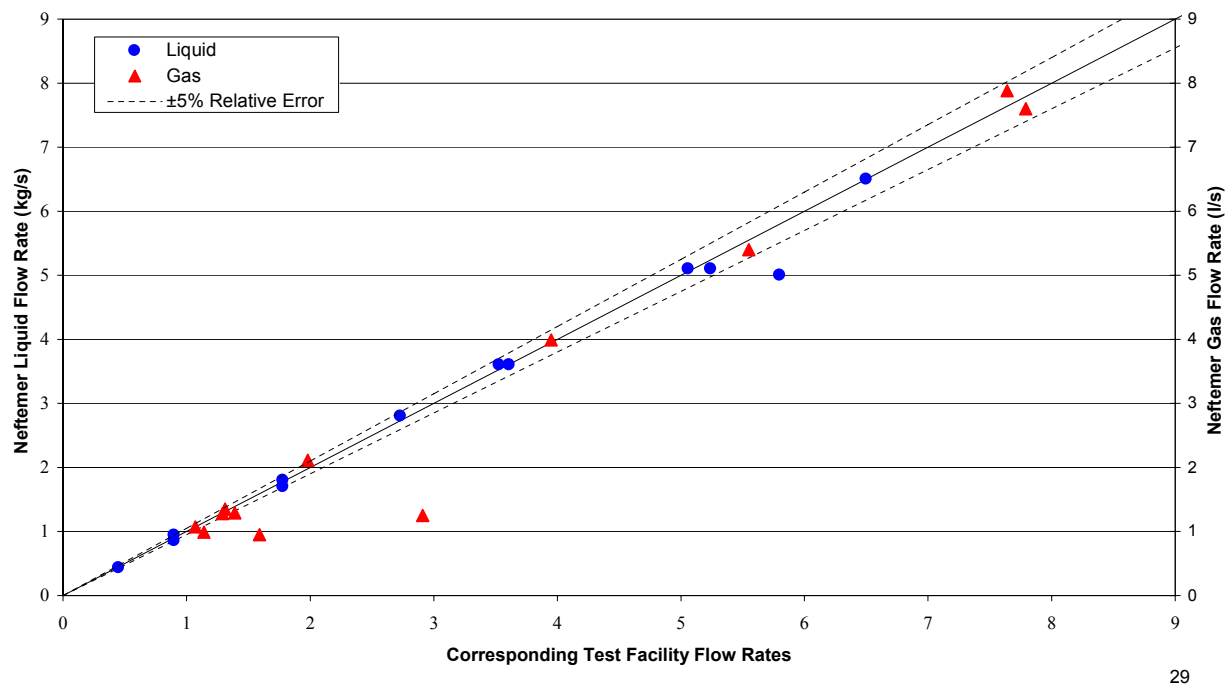
Cranfield multiphase facility



Test setup at Cranfield



Neftemer Phase Flow Rates vs. Test Facility Reference Flow Rates



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Results

- **February 2005 tests gave encouraging results**
 - Liquid and gas met target
 - Watercut showed large spread of errors
- **Further tests done in May 2005**
 - To date have not been able to make sense of these
 - Partly due to intense activity in Russia
 - Partly due to difficulties in reprocessing data
 - Operation of test loop checked
 - The two Neftemers were tracking each other
- **Warning for application of Neftemer**
 - Initially choose similar applications to Russia

Test loop / meter interaction

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- **Warning on meter/test loop interaction**
 - Much still to be understood
- **Basis of Neftemer design**
 - Measures slowly changing flow of producing wells
 - For abrupt changes in production
 - Time needed to build up statistics on new flow condition
 - Then get accurate measurements
- **Comparison with test loop time consuming**
 - At least 30 minutes per test point
 - Some test loops cannot provide stable conditions
 - For long periods
 - At high flowrates

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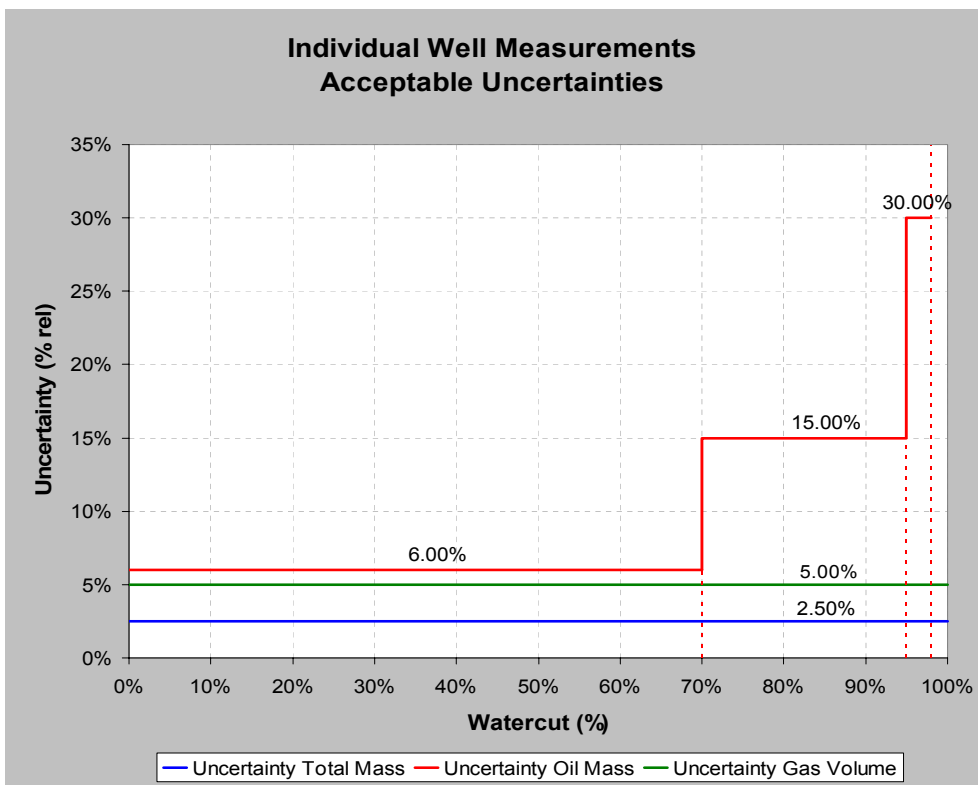
GOST R 8.615-2005

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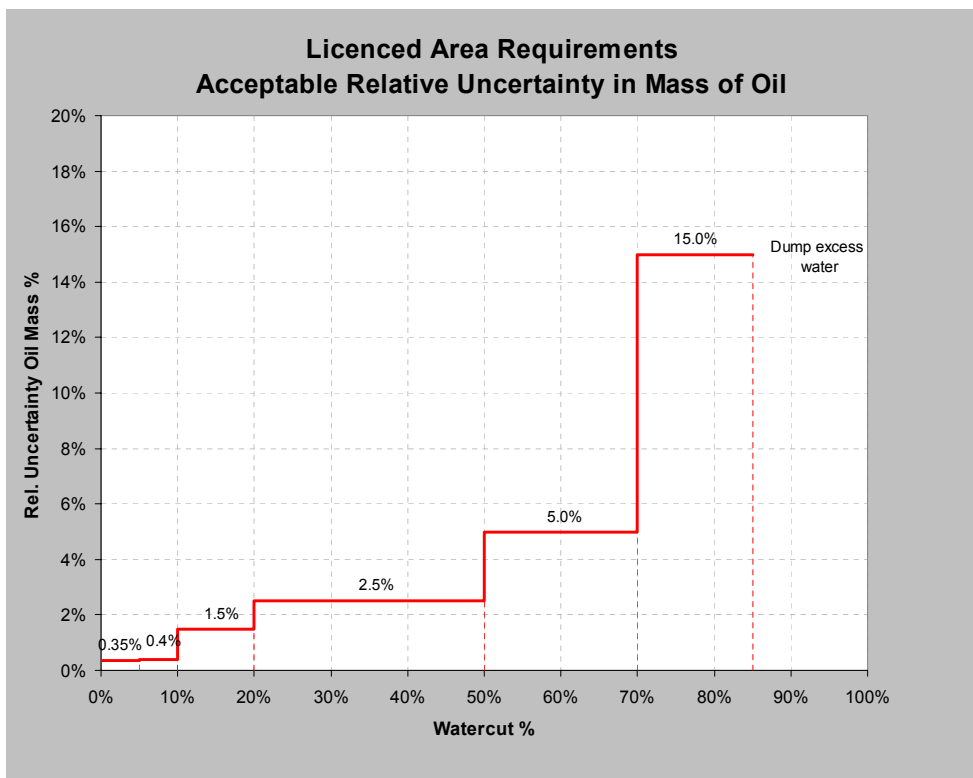
- **New Russian standard**
 - Accuracy of measurement of fluids from oilfields
 - Evidently directed mainly at oil production
- **Two categories**
 - Production of fluids from individual wells
 - Oil from “licensed area”
- **Choice of units**
 - Mass for liquid and oil
 - Volume for gas
- **Verification of accuracy to be made in the field**

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GOST R 8.615 – Individual Well



GOST R 8.615 – Licensed Area



- **1985 – Shell Field Measurements requirements**
 - Guide figure 10% relative in volume of oil, water, gas
 - Judgement to be exercised in every case
- **1995 – Oil industry requirements (NSFMW paper)**
 - Relative uncertainty in volume of liquid and gas
 - Reservoir management 10%; Production allocation 5%
 - Absolute uncertainty in watercut
 - Both cases 2%
- **2005 – Uncertainty based allocation**
 - Only small adjustment to accurate producer
 - BUT how does one obtain valid uncertainty figure???

- **GOST document suggests practical approach**
 - BUT sets a difficult “pass” figure (2.5% total mass)
 - Better to use the approach to determine “uncertainty figure” and let users decide how to apply?
 - Mass primary unit for oil
 - Extend to gas as well?
- **Uncertainty based allocation**
 - The way forward for multiphase systems?
 - Use GOST approach to determine operating uncertainties?
- **Multiphase meter verification**
 - Test labs to develop suitable transfer standards?
 - Emphasis should be on practical field methods

Conclusions - Neftemer

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- **Neftemer development extends over 25 years**
 - Non-intrusive measurement principle can work
 - Lower production, artificially lifted, land based wells
 - Wide range of crude oils, especially heavy, high watercut
- **Field calibration method practical**
 - Based on separator on weighbridge
 - Should be considered for Western applications
- **Challenge to thinking behind use of test loops**
 - Need to combine field and laboratory methods
- **Warning when tackling new applications**
 - Non-intrusive Neftemer can assess applications
 - Prior to deciding on permanent installation

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Conclusions - General

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- **Perception that multiphase metering is a mature technology**
 - 0.2% market penetration suggests not
 - about 2000 meters for 1 million wells worldwide
 - We consider impact is just beginning to be felt
- **Diverse range of meters and equipment required**
 - Neftemer a cost-effective and versatile addition to that range
- **Practical standards beginning to appear**
 - Verification techniques for field use
 - Allocation in multi-producer systems with different accuracies
- **Need to extend international co-operation**

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