Neftemer Ltd

Cranfield UNIVERSITY

North Sea FLOW Measurement Workshop

NEFTEMER
a versatile and cost effective multiphase meter

by

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Neftemer - overview

- Objective of paper
  - To bring metering community up to date with Neftemer story
  - A different approach to multiphase metering
  - Different applications
    - Heavy oil, relatively low producers

- Outline of Neftemer development
- Field test results
- Laboratory test results
- Conclusions

Western approach

- Multiphase metering development
  - Began in late 1970s /early 1980s
  - 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

Neftemer – late 70s to 1990

- Request from Russian oil companies
  - Solutions for measuring “unseparated” flow
  - Land wells, lowish production, heavy oil
- V. Kratirov at Space Institute in St Petersburg
  - γ-ray meter for steam/water flows in nuclear reactor
  - Based on interpreting fast fluctuations in density
  - Could be adapted for oil industry
- Field research in Belorussia
  - Data from wells gathered over several years
  - How best to deploy detectors

Neftemer – late 70s to 1990

- Additional expertise required
  - V. Kratirov originally not flow expert
  - Involved Russian flow experts as consultants
  - Involved experts in statistical data processing
- Practical methods for gathering field data
  - Separator tank on weigh bridge (gas not important)
  - Oil and water from interface measurements
  - Mass units the automatic choice
- Development of fluid model and algorithms
  - Calculate phase flowrates and integrate to get totals
  - Compare with totals from test tank, adjust parameters

Neftemer – late 70s to 1990

- ‘PULSAR’ meter designed 1988
  - Approval required from State Authorities
  - Covered comparison method, performance criteria, supervising tests and preparing report
- Commercial prototypes
  - 10 ordered in 1989 for testing in three oil companies in Belorussia, Russia and Kazakhstan
- Tests showed
  - There was a major need to measure lower liquid production rates
  - It was essential to be able to measure watercut

Neftemer – 1991 - 98

- 1991 Complex Resource set up
  - To develop improved meter, in line with test findings
- Intrusion of “real world” issues
  - Collapse of former Soviet Union
    - Research funding suspended
  - Collapse of Soviet manufacturing industry
    - Firm which manufactured ‘PULSAR’ out of business
  - V. Kratirov had effectively to start again
  - Major financial crisis (1998 rouble crisis)
  - Collapse of oil price
- All in all, a difficult period

‘Neftemer’ appears

- In 1995 new prototype appears targeting
  - thermally stimulated, high watercut, heavy oil wells
    - Flowrates 5 – 300 tonnes/day (about 30 – 1800 bbl/day)
- Tests 1995/96 at Langepas
  - Contract for yet more advanced version
    - Tested 1997 in commercial operation
    - Signal processing improved (5% accuracy for 70% of points)
    - Certification for meter achieved
- Tests 1998 at Langepas
- Shortcomings of earlier versions removed
    - Acceptable as flow rate indicator
    - Submitted to State Register of Measuring Equipment

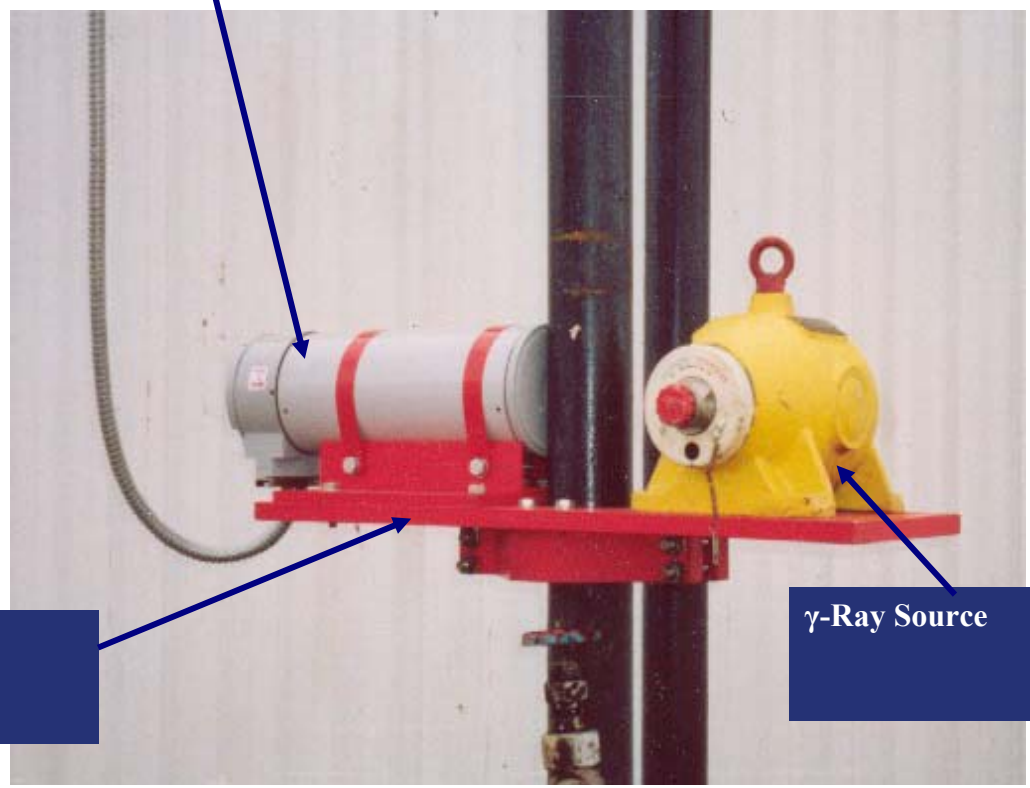
Neftemer – 1998 to present

- Operational tests 2001
  - Komi Republic
- Large scale installation
  - By end 2005, 50 wells operating with Neftemers
  - Heavy oil, thermally stimulated
  - Installed as multiple assemblies
  - During 2006, further 150 wells operating
- Benefits other than metering
  - Detecting faults, need for well wash, detecting leaks
- 2006 test at gathering station

Neftemer outside Russia

- 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 construction



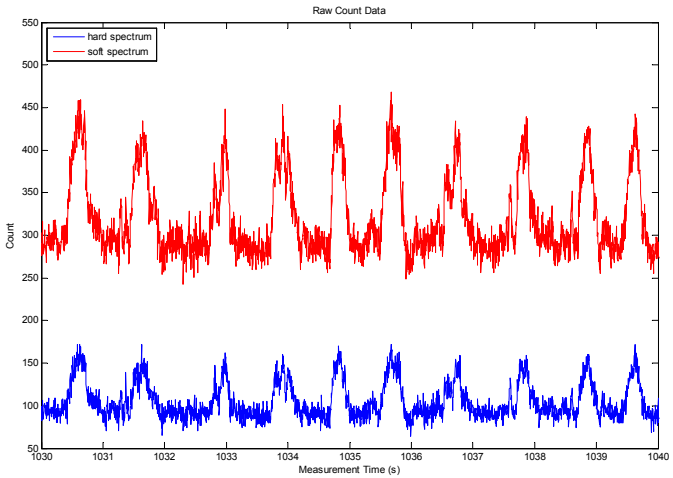
Neftemer installations

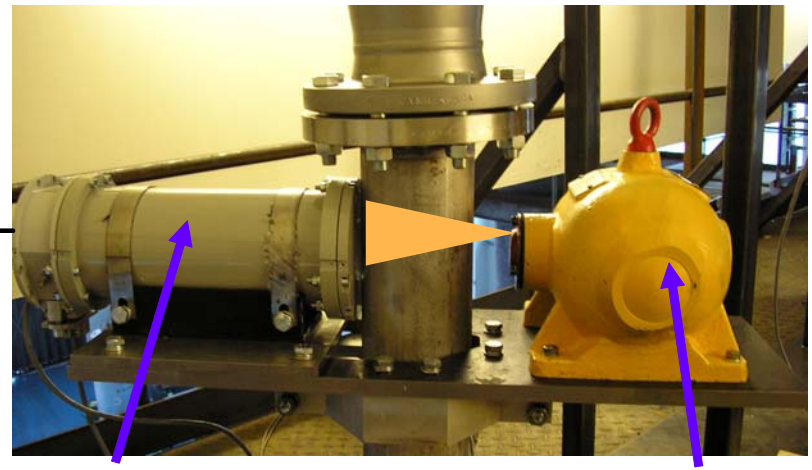
Single meter on beam-pump well

Prototype in field installation

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

Neftemer operation





Detector

Gamma Source

Advanced Signal Processing

Satellite Link

Gas Flow Rate

Oil Flow Rate

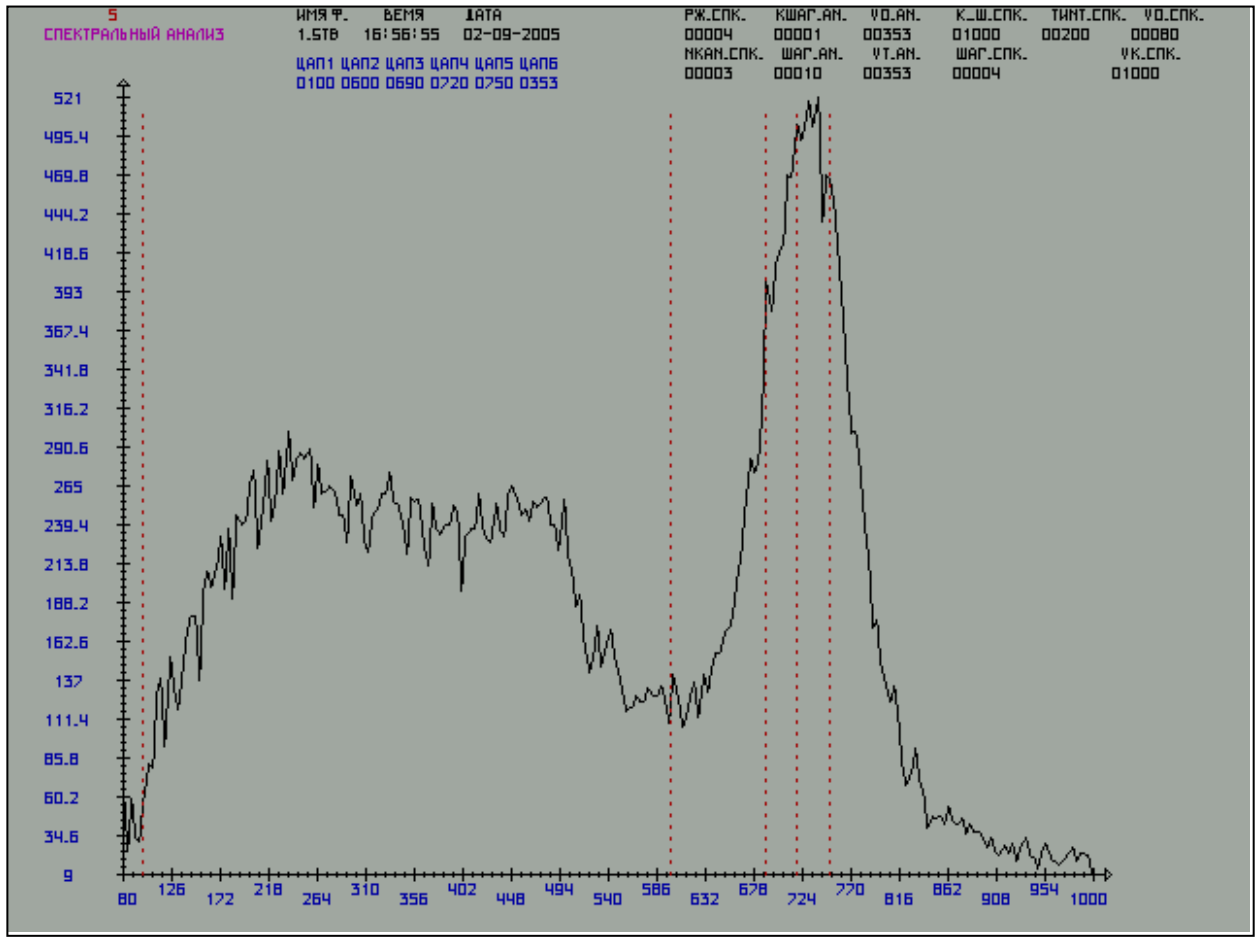
Water Flow Rate

Secure Data Connection

Local Display

Remote Display

Detected Spectrum



How it works - Basics

- 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

How it works - Velocities

- 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

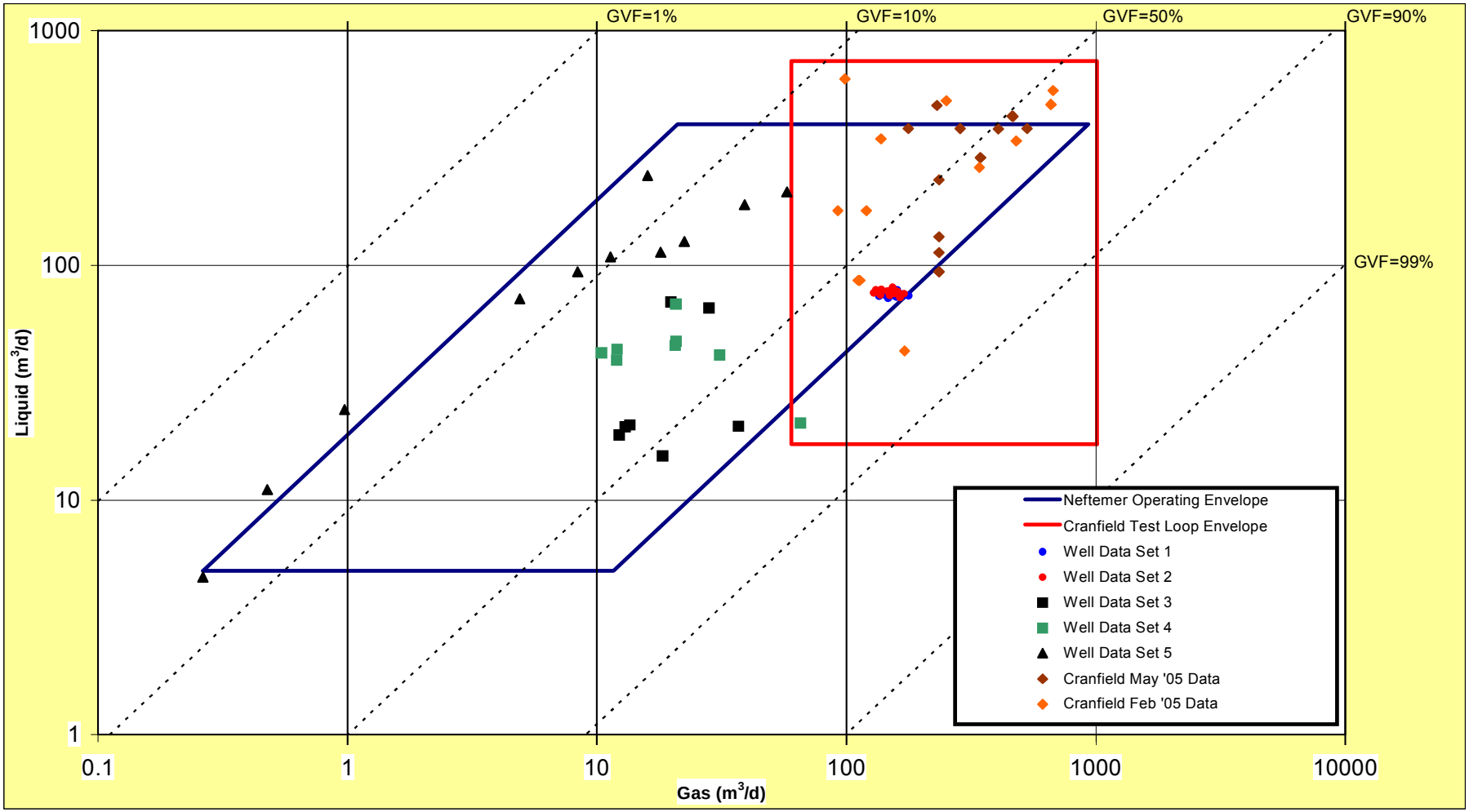
How it works – Phase fractions

- 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
- Phase fractions and liquid and gas velocities
  - Combined with area gives phase flowrates

How it works – In practice

- 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

Operating envelope



Field testing

- Earlier field tests (1995/96, 1998, 2001)
  - Show improvements and moves to heavy oil
  - Discussed in 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/m^3)

“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 vertical sections of 3-phase pipelines from fields
    - One 325 mm pipe, two 219 mm pipes
    - 325 mm pipe conveyed >99% of total production
- Set up equipment, then seal for one month
  - Independent comparison of daily production totals
  - Data shown is from 11-day preliminary period of test

Results of 2006 test

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**

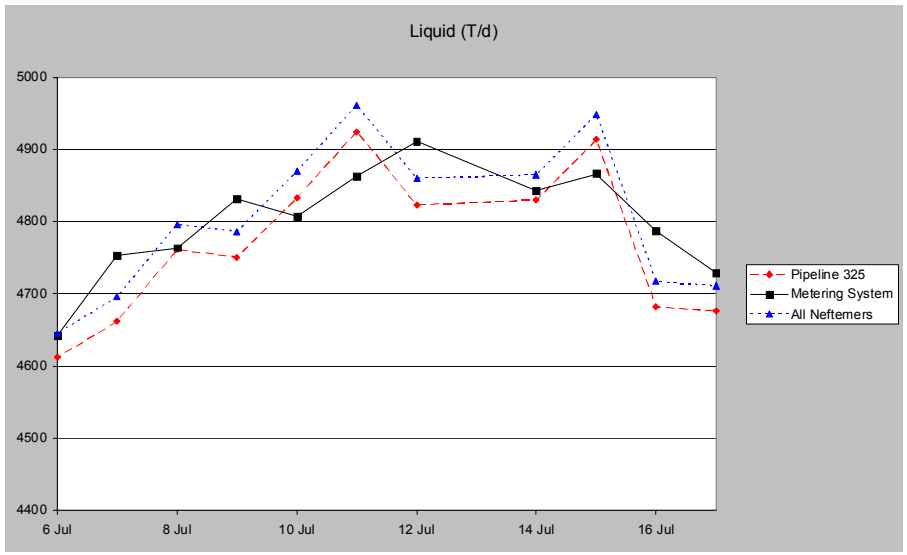
Observations on test - 1

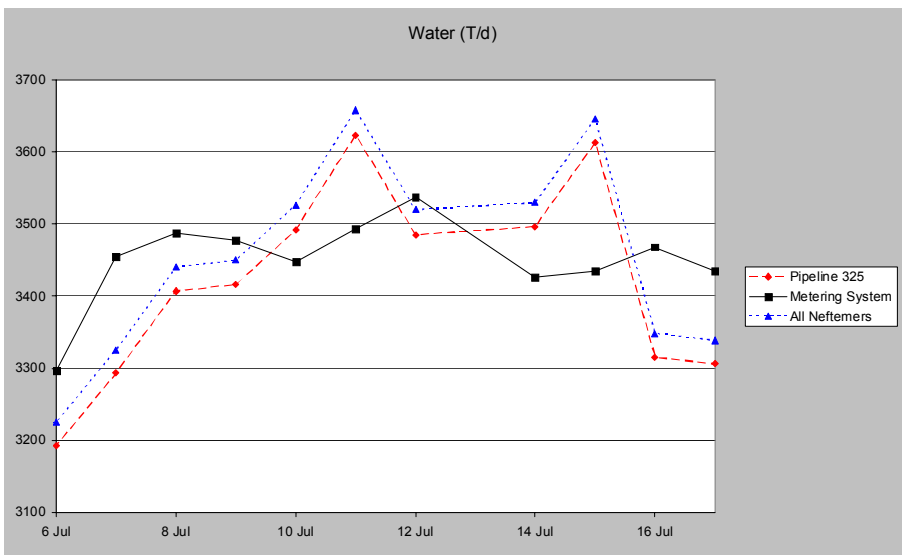
- Low average errors in daily production totals
  - Liquid 0.11%, water 0.12%, oil 0.25%
    - Indicates daily variation was mostly random
- Average errors for pipe 325 (e.g. liquid -0.63%)
  - Reflect introduction of systematic error
    - Smaller pipelines transporting mostly water
    - Neftemer could see small changes in multiphase flow
- 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
    - Results indicate 2.4% liquid and 3.5% watercut

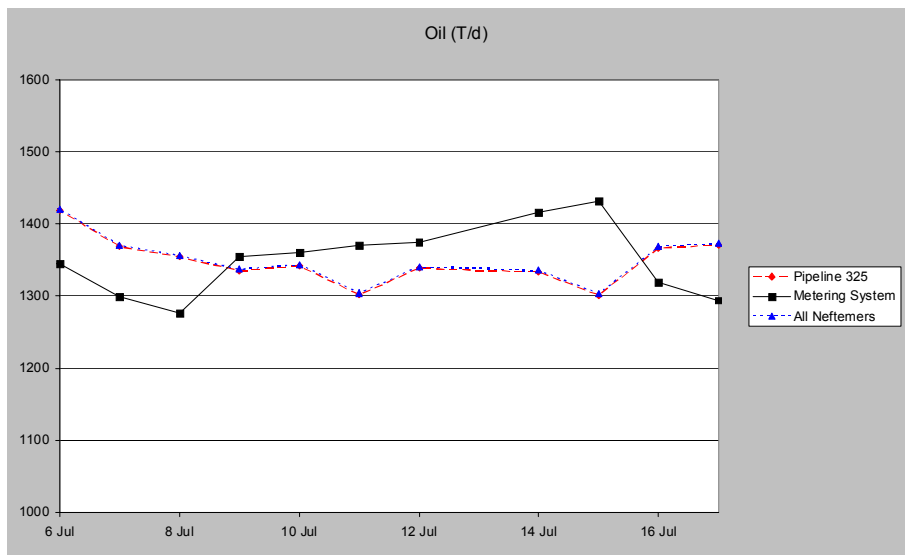
Observations on test - 2

- 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

Comparison of daily totals





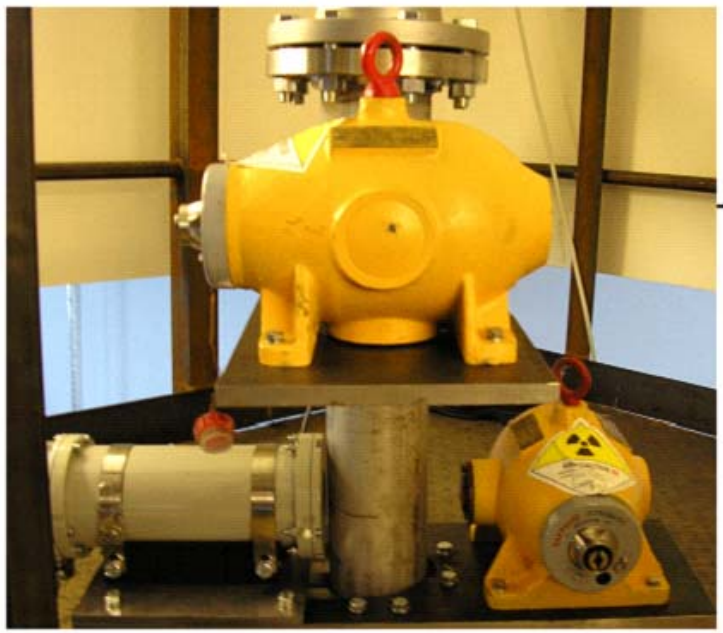


Laboratory testing

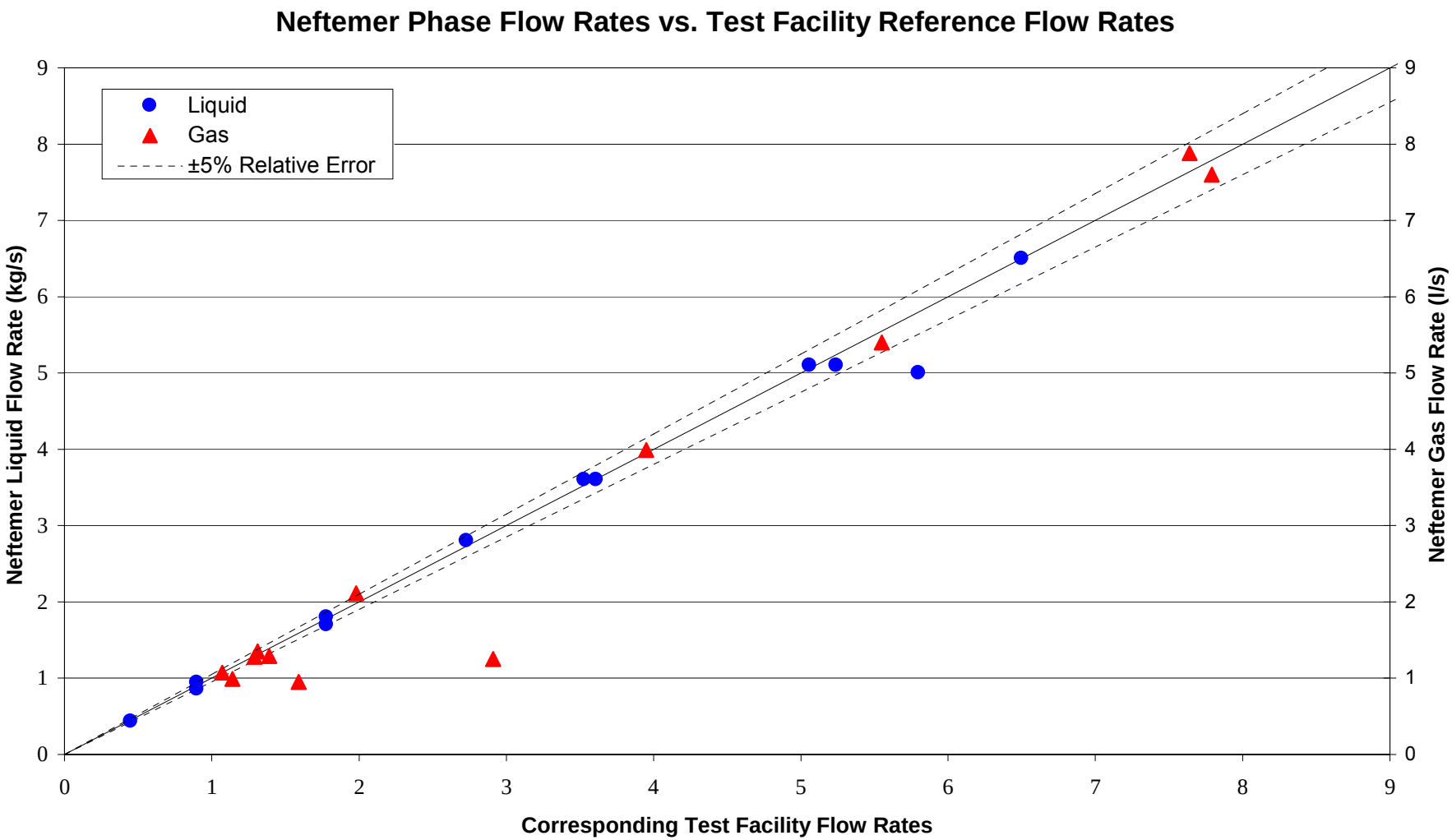
- Using Cranfield University multiphase facility
- Test programme based on Multiflow 2 JIP
  - To give direct comparison with other meters
  - Subset of test points
- Significant differences from field conditions
  - Stainless steel versus carbon steel pipe
  - Light lubricating oil versus heavy oil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

Cranfield multiphase facility

Test setup at Cranfield



Liquid and gas comparisons



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

- 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

Conclusions

- 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

Conclusions

- 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 is a cost-effective and versatile addition to that range