Bubble Breaker*

Production enhancement in gaslifted or naturally producing wells with associated gas

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Shell

*Patent pending

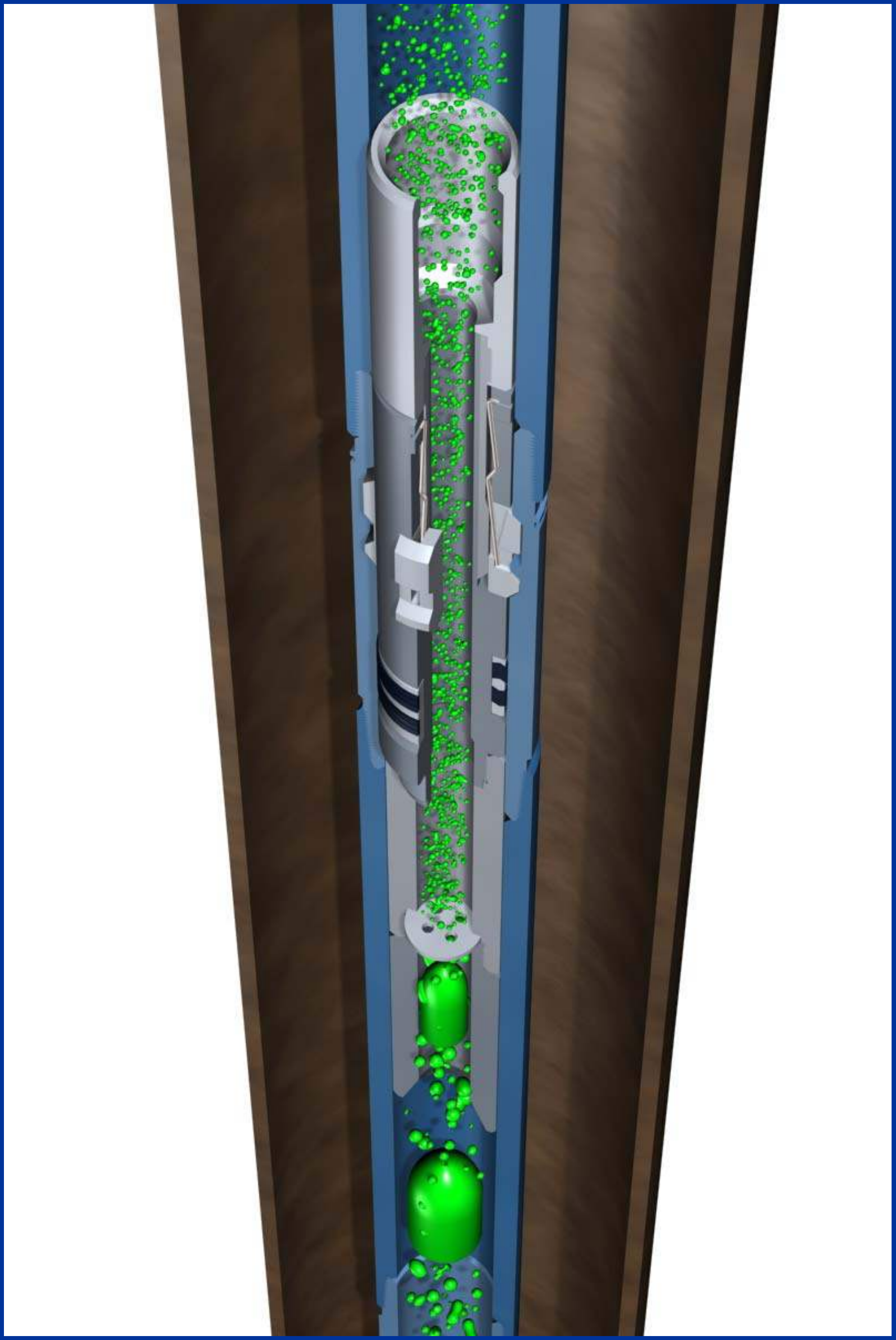
Development history

Phase	TRL	Description	When
Discovery	0	Opportunity identification	November 2001
	1	Opportunity analysis	December 2001
	2	Selection most promising approach	January 2002
	3	Critical risk reduction	March 2002
	4	Feasibility demo	May 2002
	5	Proof of concept	July 2002
Development	6	Test technology	September 2002
	7	Prototype	June 2003
	8	Trials	2004
Deployment	9	Deployment	2005

Working of Bubble Breaker

Break-up large bubbles and slugs into small dispersed bubbles by inserting a wireline retrievable device in the tubing, which creates intense liquid turbulence.

Generated bubbles are so small that they hardly coalesce downstream of the bubble breaker



Vertical Lift Performance

Pressure loss is dominated by hydrostatic head:

$$\Delta P \cong \rho_l \, (1-\alpha) \, g \, h$$

Gas hold up

Higher gas hold up = Lower hydrostatic head = Lower bottom hole pressure = Higher production

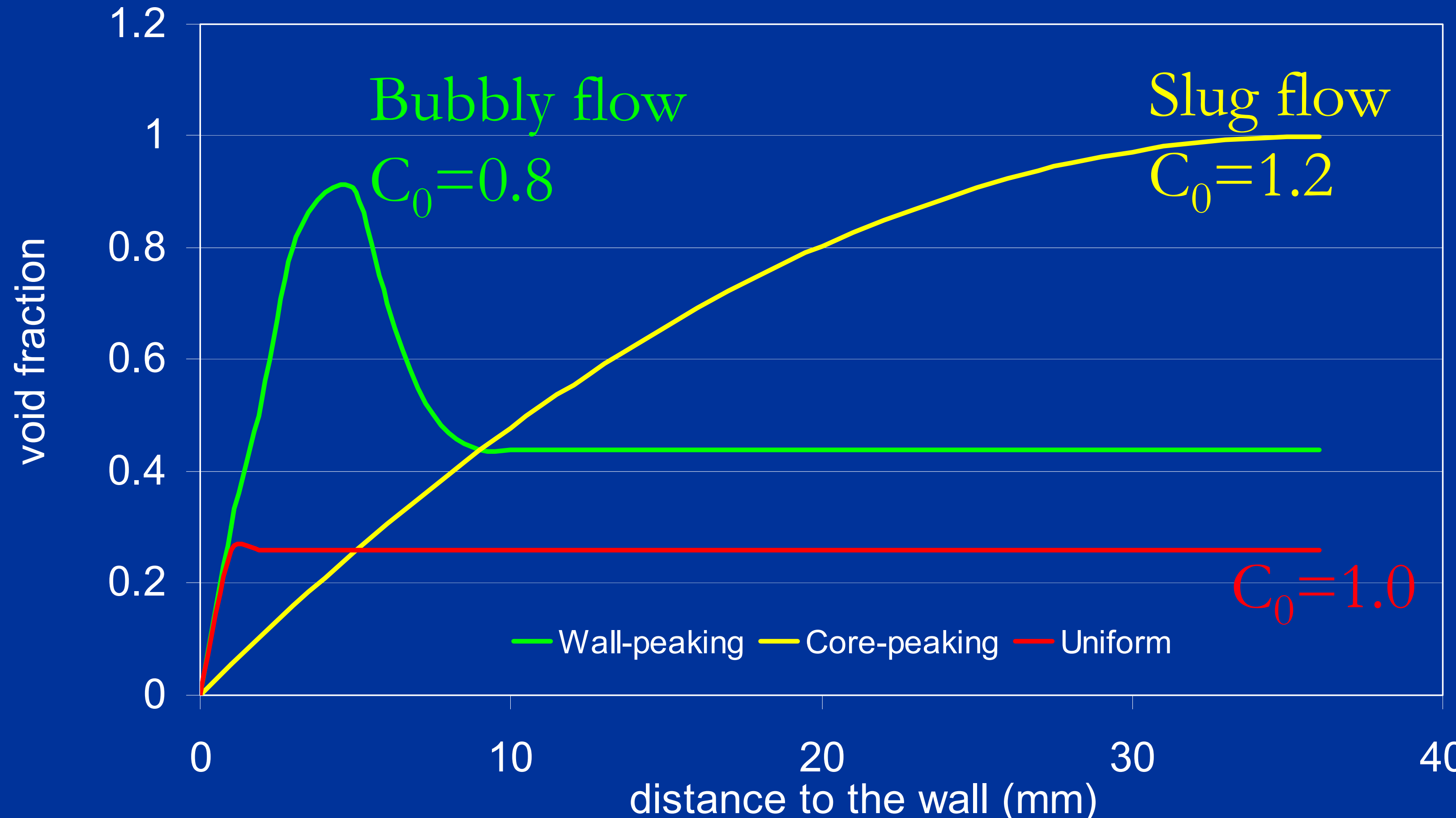
Drift flux model

- The drift flux model relates the actual gas velocity to the center line velocity and the bubble rise velocity

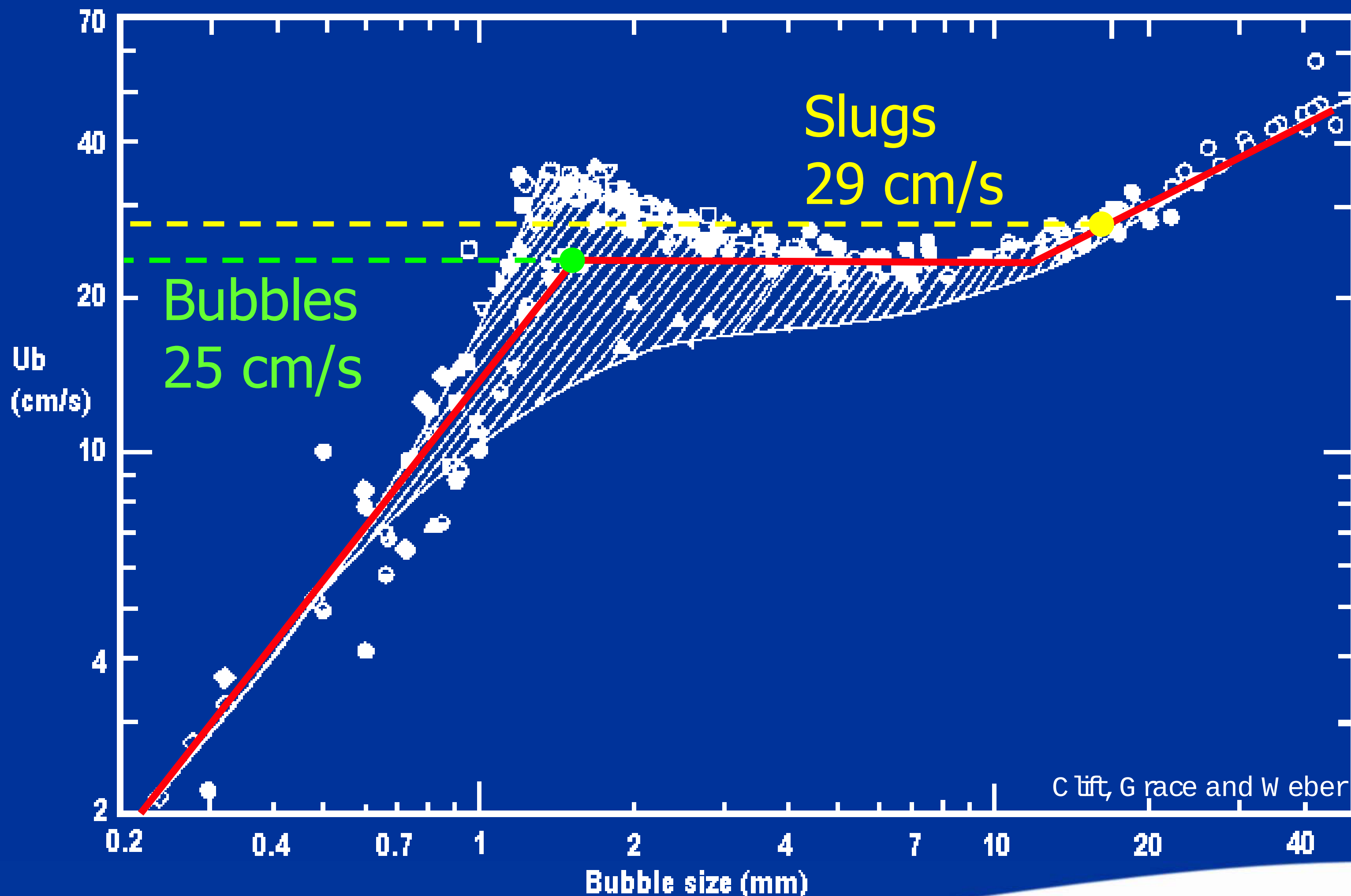
$$\alpha = \frac{U_{sg}}{U_g} = \frac{U_{sg}}{C_0 U_m + U_b}$$

- Void fraction increases when C_0 and U_b are reduced

C_0: distribution parameter



Bubble rise velocity



Small bubbles

SMALLER BUBBLES…

… have higher area-to-volume ratio. The slip of the gas phase is then lower, resulting in a longer residence time in the well.

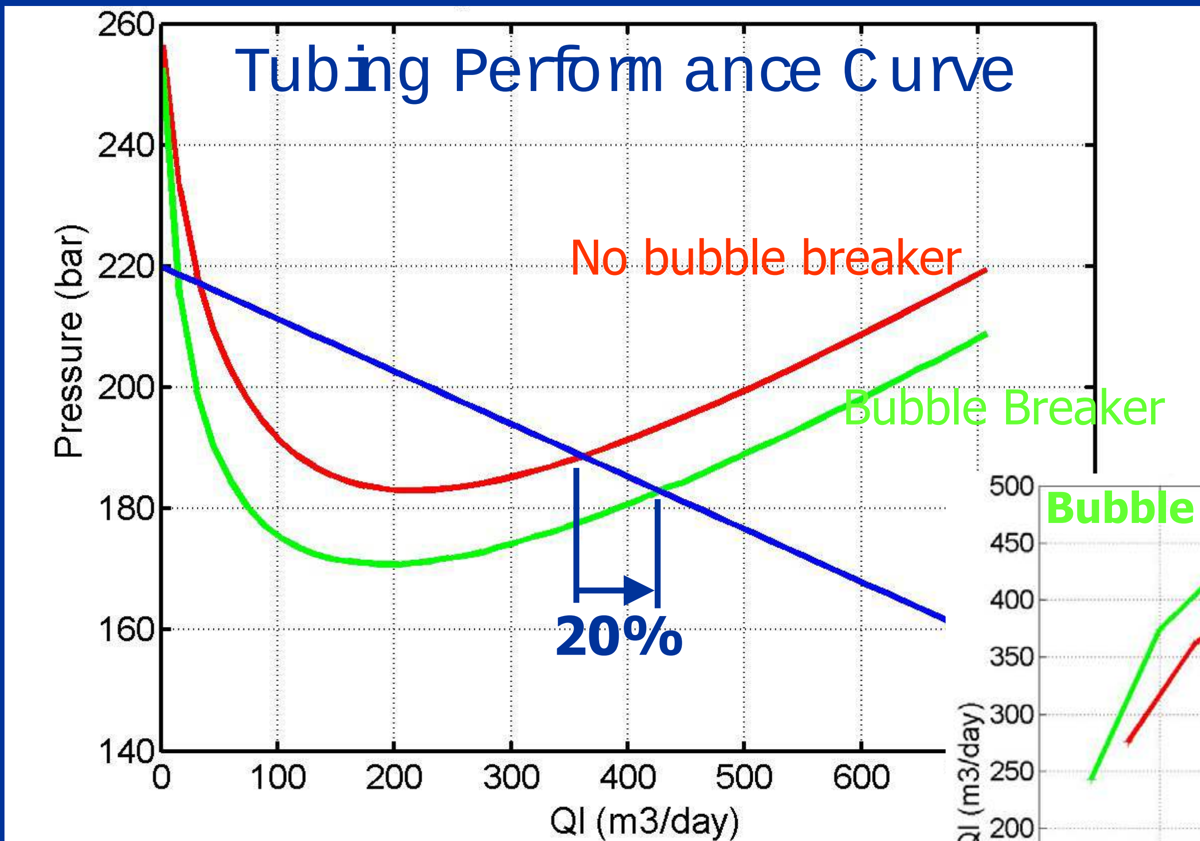
… are more homogeneously distributed over the pipe cross-section.

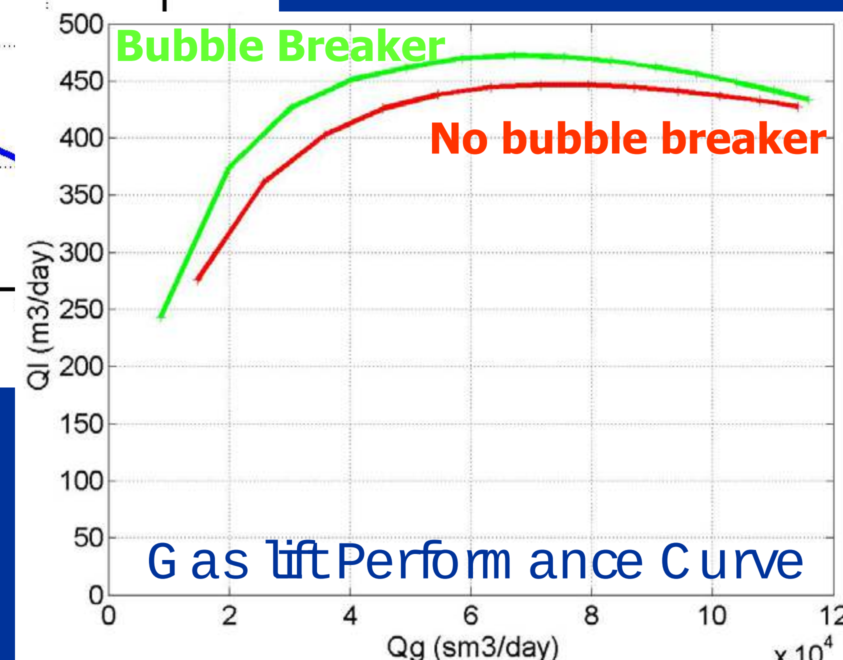
… postpone the transition from bubbly to slug flow.

RESULT:

The gas hold up is increased, the bottom hole pressure reduced and production increased.

Modeling Results





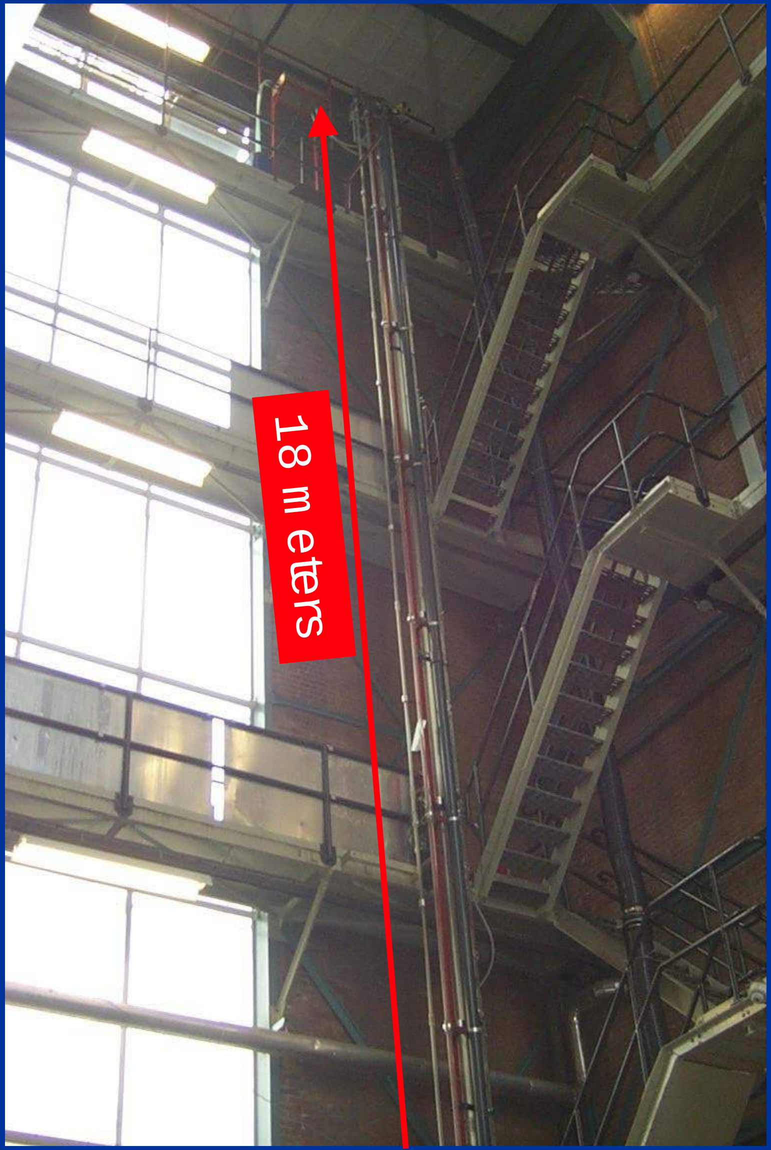
Depth = 3000 m (10.000 ft)

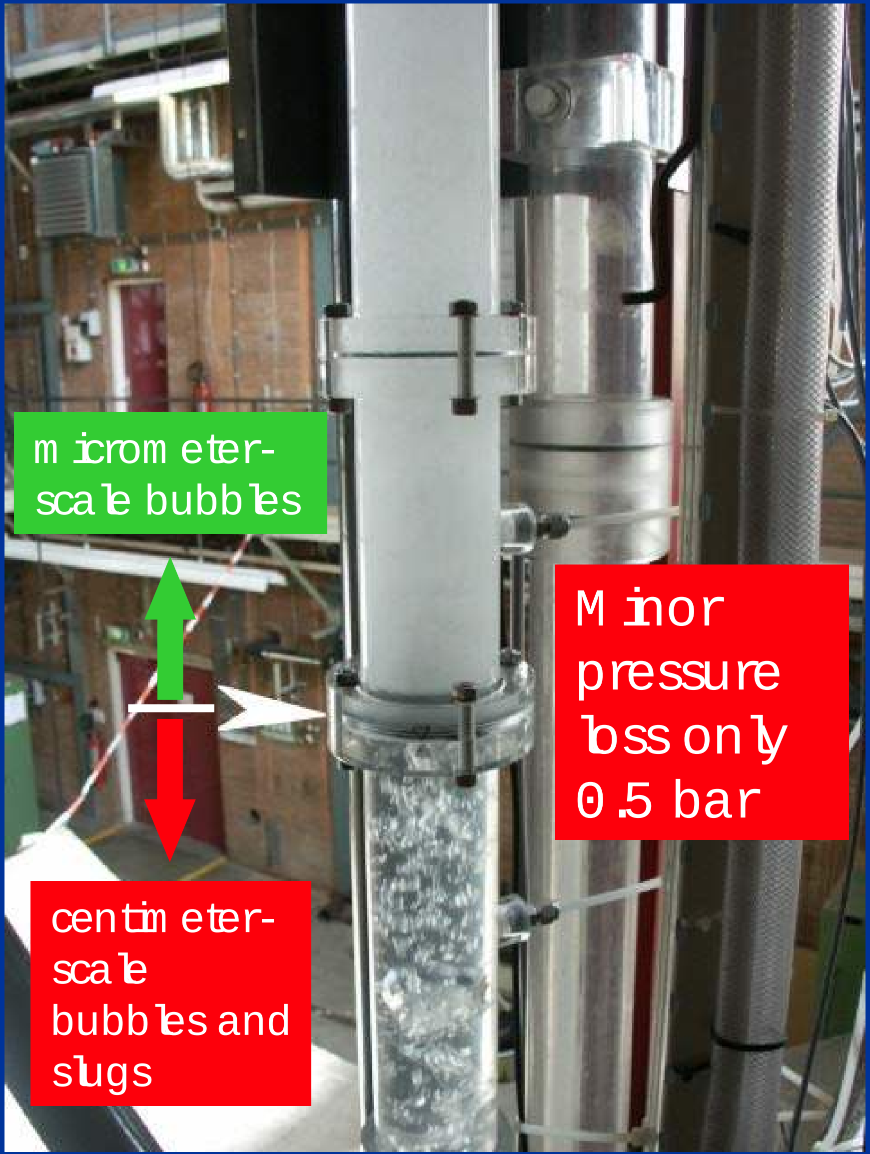
GLR = 70 sm^3/m^3 (400 scf/bbl)

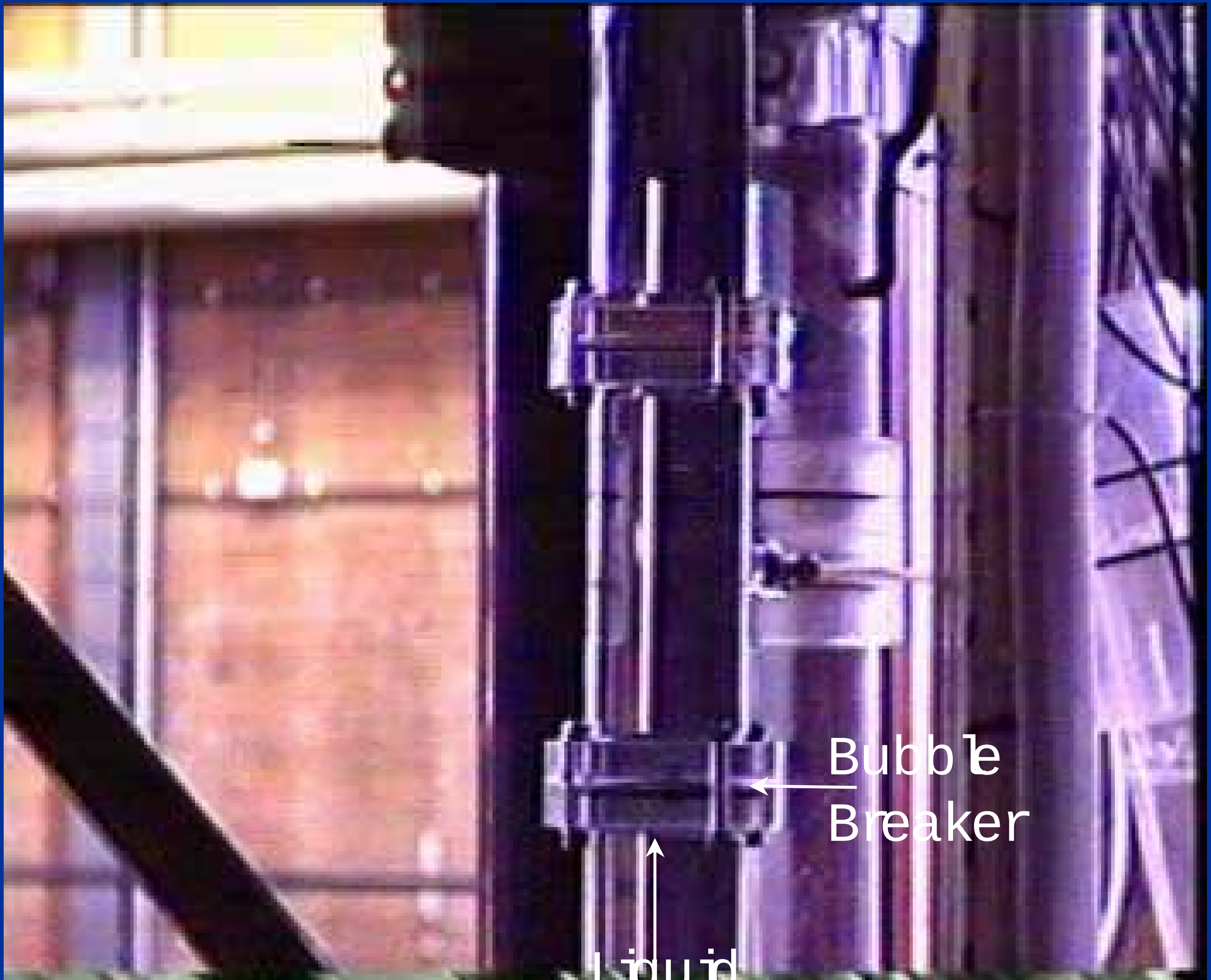
PI = 12 $m^3/d/bar$ (5 bpd/psi)

Production = 355 $m^3/d \Rightarrow$ 425 m^3/d

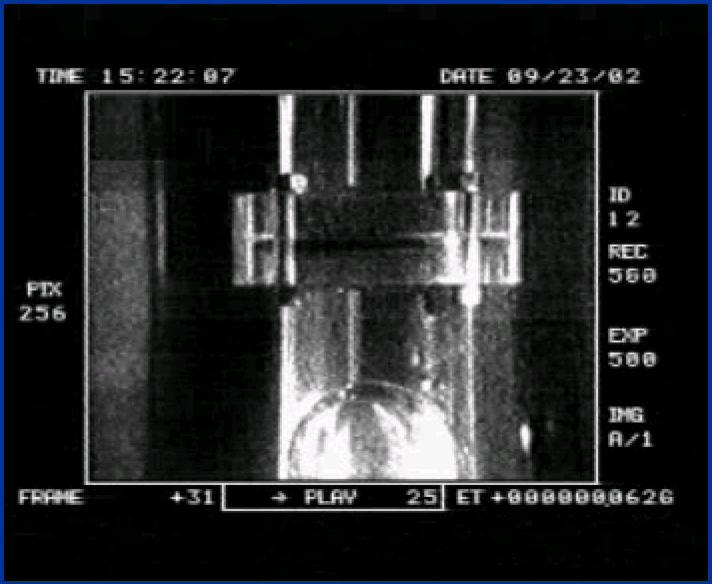
Experiments in Shell-Rijswijk






Bubble
Breaker
Liquid

Slow motion



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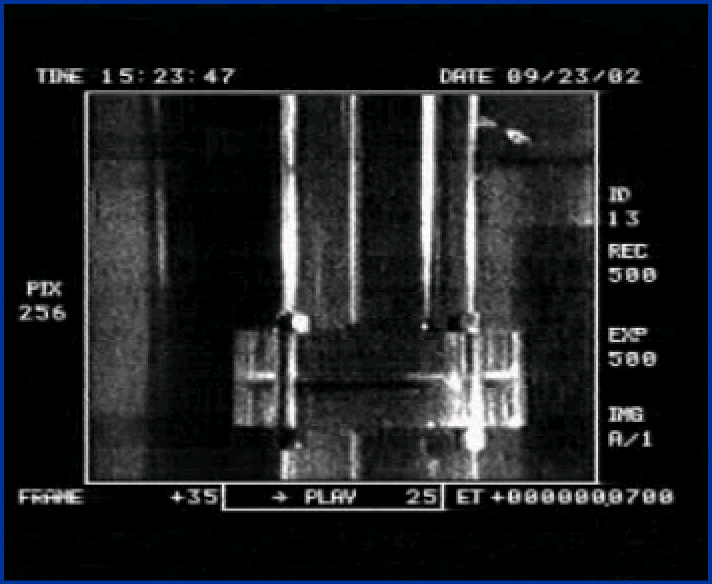

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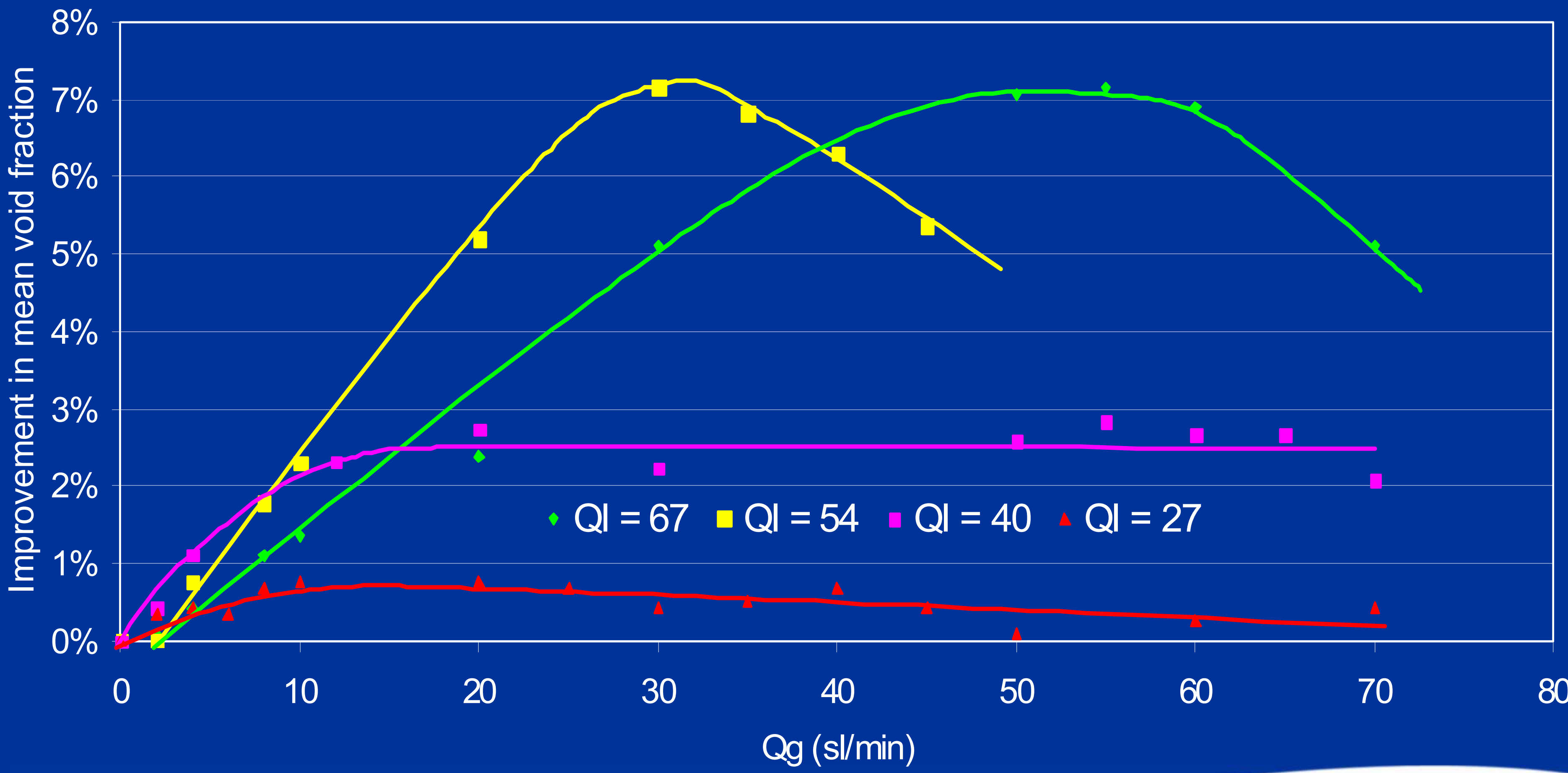
Laboratory results

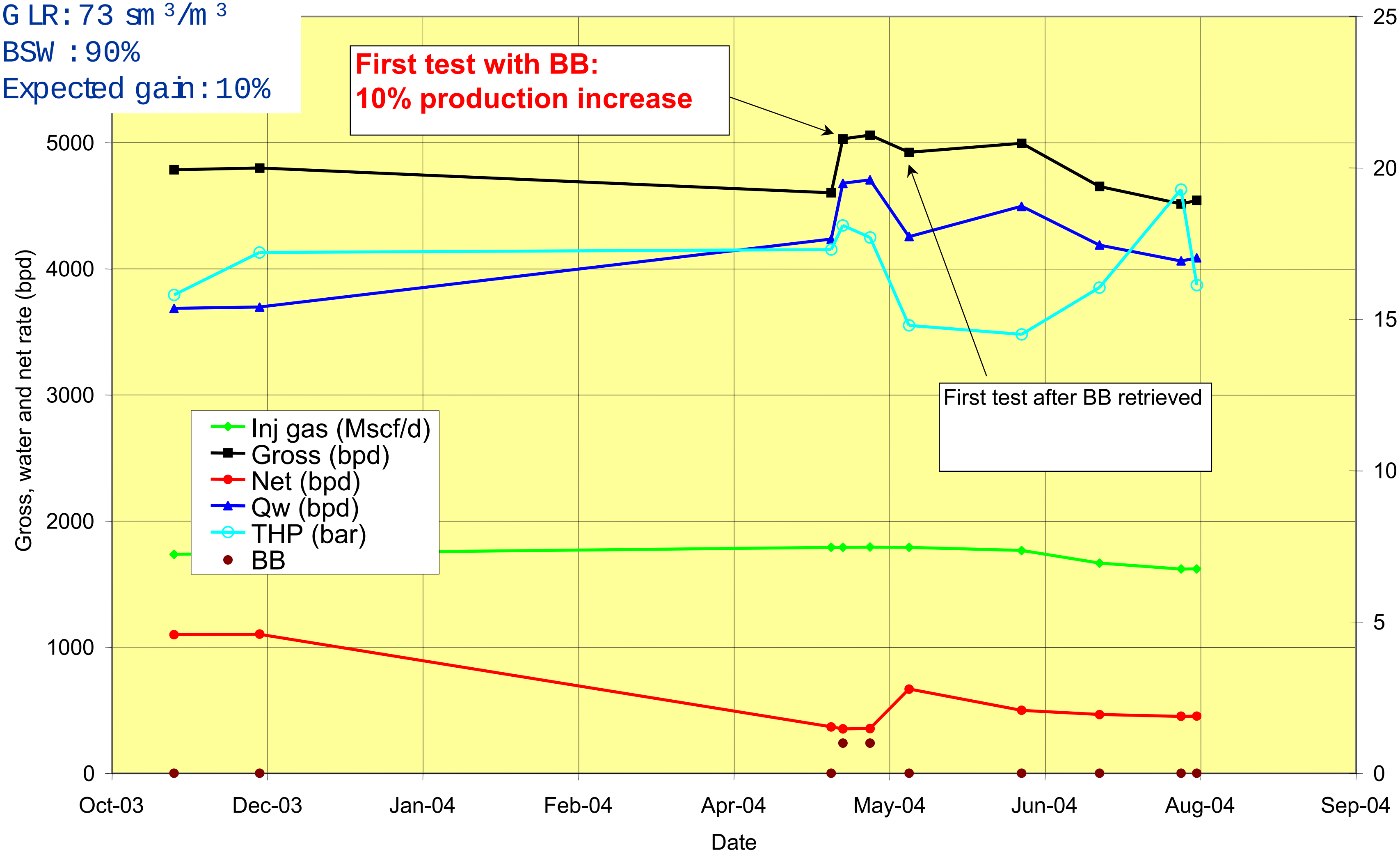


Summary of experiments

	Without bubble breaker	With bubble breaker
Bubble size	4-16mm	< 1mm
Bubble rise velocity U_b	25 cm/s	10 cm/s
Distribution parameter C_0	0.8 and 1.2	1.0 and 1.2
Critical void fraction	15%	35-55%
Increase in void fraction		7%
Pressure loss		0.5 bar

Results Field trial

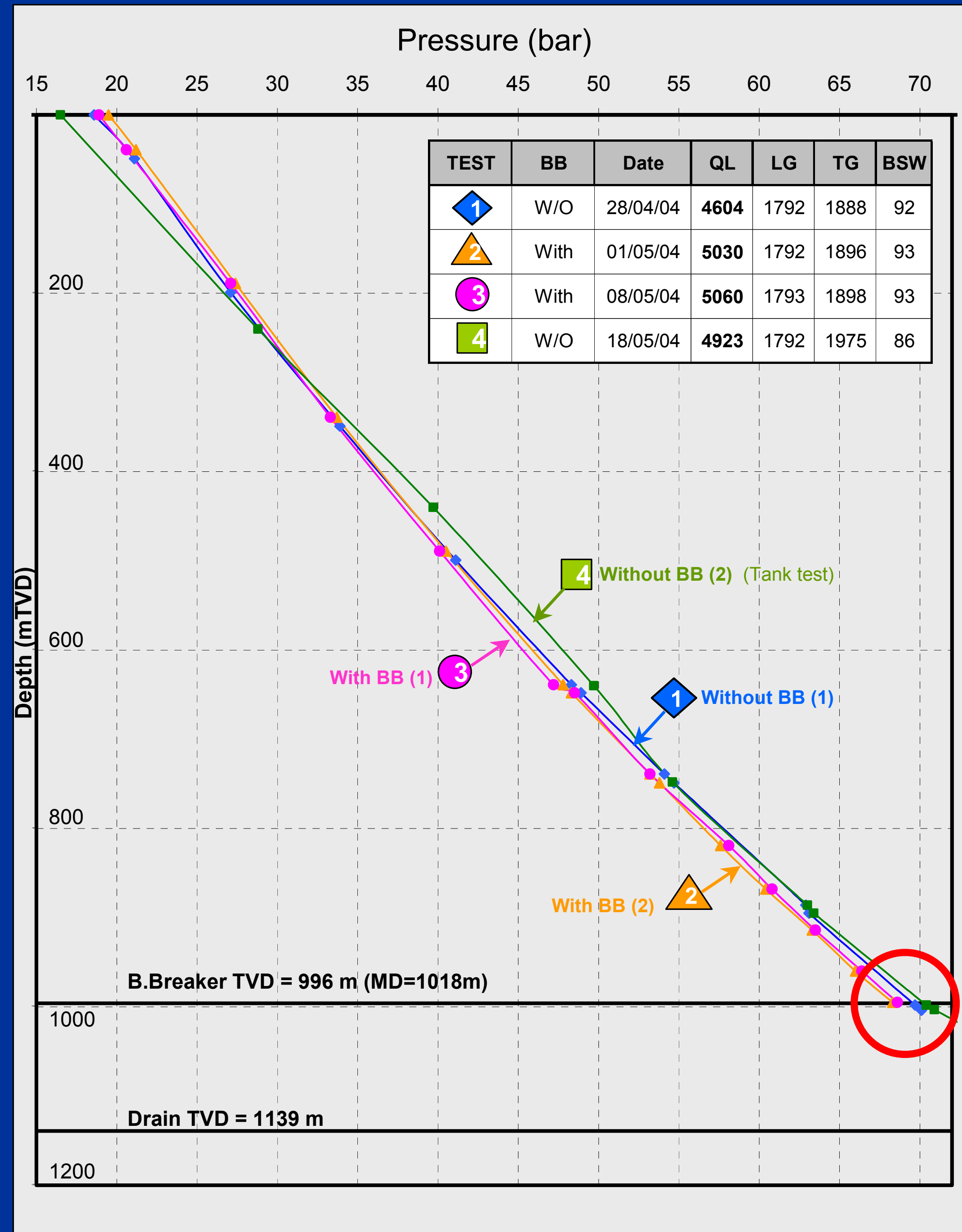
Depth: 1000 m TVD
Tubing: 4 1/2”
GLR: 73 sm³/m³
BSW : 90%
Expected gain: 10%



FGS

Rough estimates:

- Pressure reduced by ~ 2 bars
- dP_{bb} = 1.8 bar (from model)
- dFBHP = -0.2 bar (3 psi)
- dQ = 150 bpd/psi * 3 = + 450 bpd
- In line with model (+ 10%)



TEST	BB	Date	QL	LG	TG	BSW
1	W/O	28/04/04	**4604**	1792	1888	92
2	With	01/05/04	**5030**	1792	1896	93
3	With	08/05/04	**5060**	1793	1898	93
4	W/O	18/05/04	**4923**	1792	1975	86

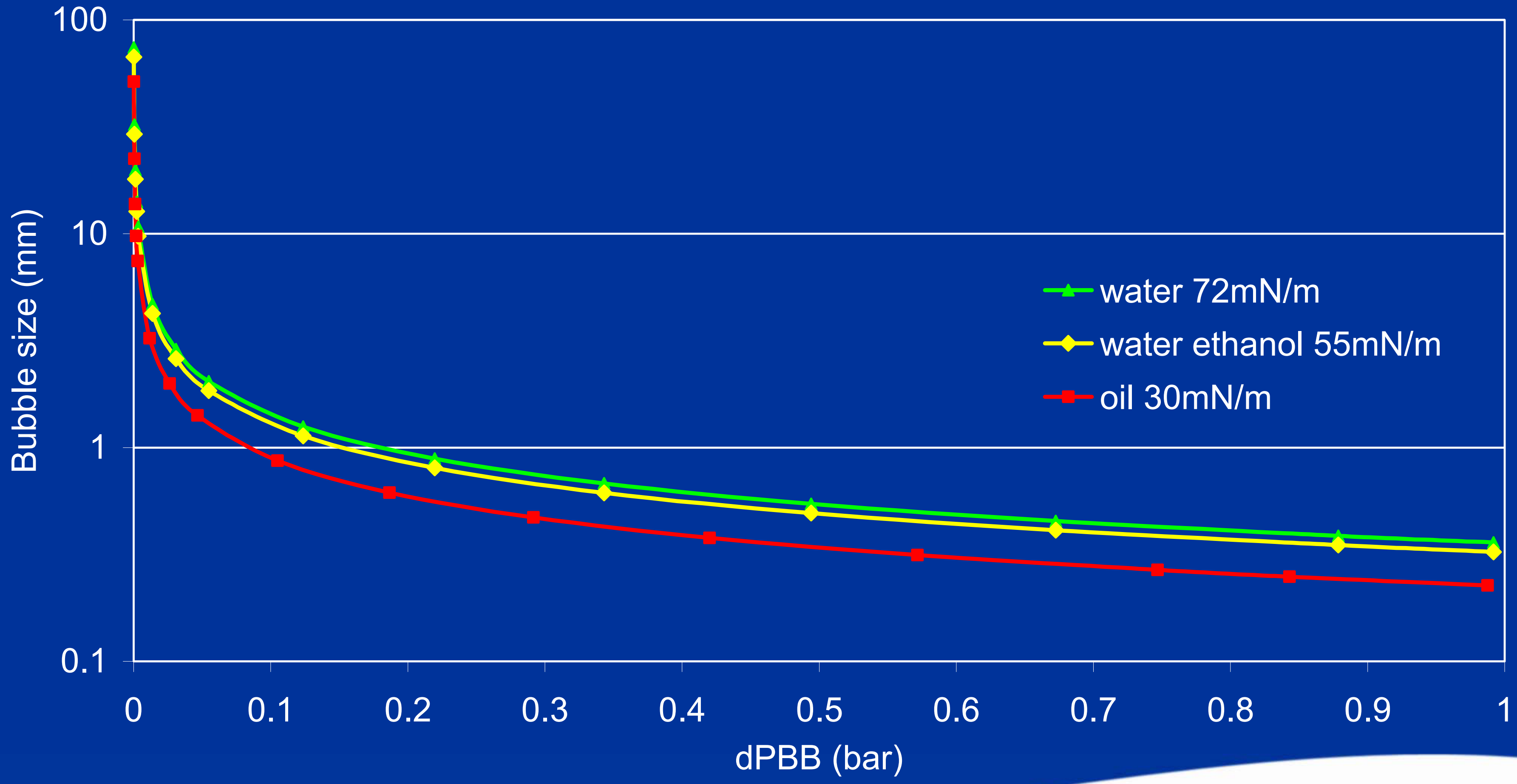
Summary

- Small bubbles are beneficial for gas lifted wells and naturally producing wells with associated gas
- A bubble breaker can be used to generate these small bubbles
- Concept is proven in laboratory
- First field trial shows promising results

Acknowledgements

- Richard Fernandes
- Michiel Visser 't Hooft
- David Lee
- Jim Hall
- Jeanet Israel-Schouten and Maria Pena
- Nick Zdenkovic and Satinder Malik

Bubble size



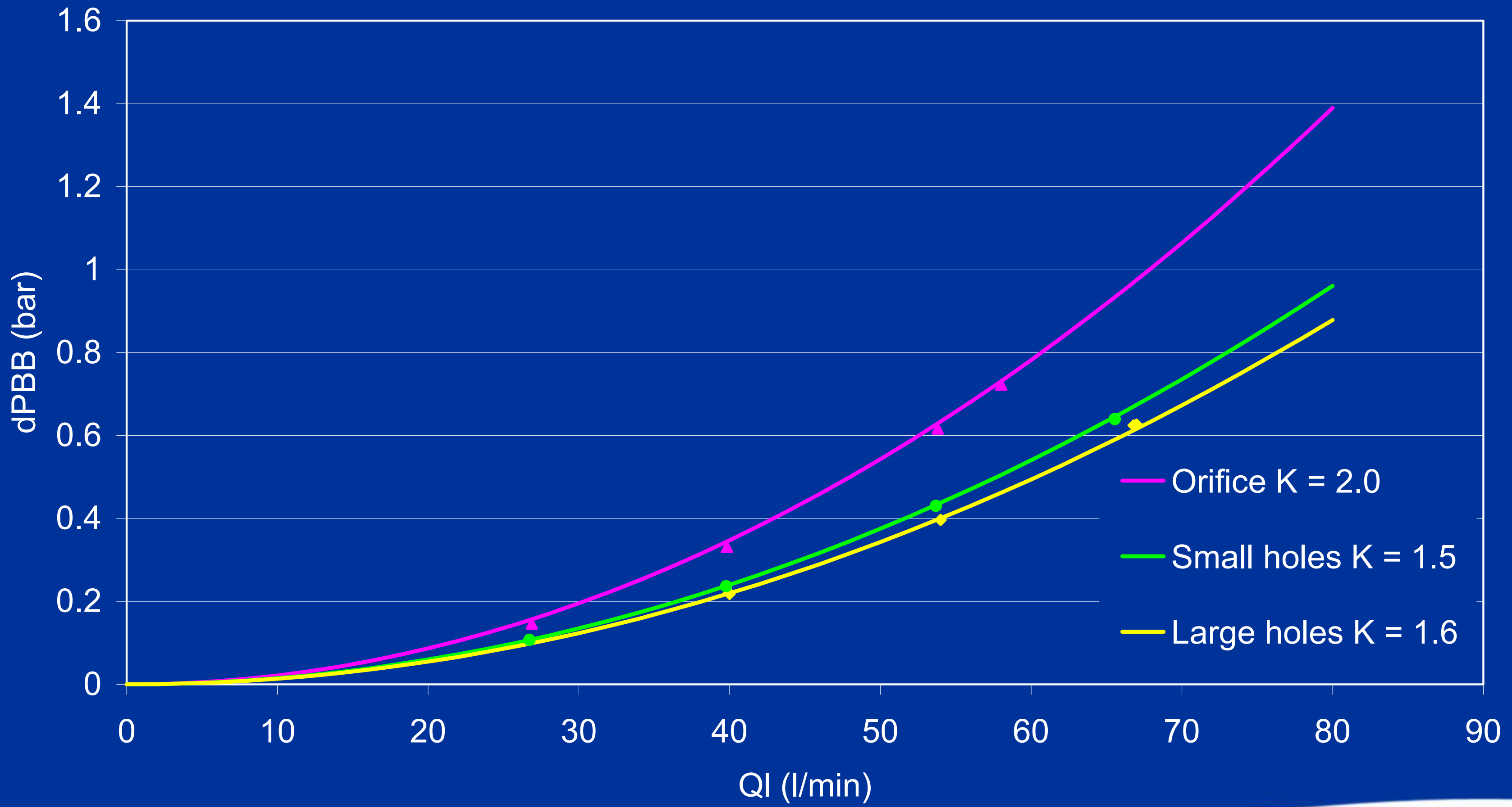
100
10
1
0.1
Bubble size (mm)
water 72mN/m
water ethanol 55mN/m
oil 30mN/m
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
dPBB (bar)

Pressure loss over bubble breaker

$$\Delta P_{bb} = \phi^2 \frac{1}{2} K \rho_l U_l^{\,2}$$

Lockhart-Martinelli correlation

Single phase pressure loss over the bubble breaker



Two-phase pressure loss over the bubble breaker