Practices in the Production Enhancement and Cost Optimization in CE European Region

Workshop

Visegrád, 16 November 2017

Society of Petroleum Engineers

Liquid loading Prevention for Low Capacity Gas Wells

Rethinking of Old Stuffs

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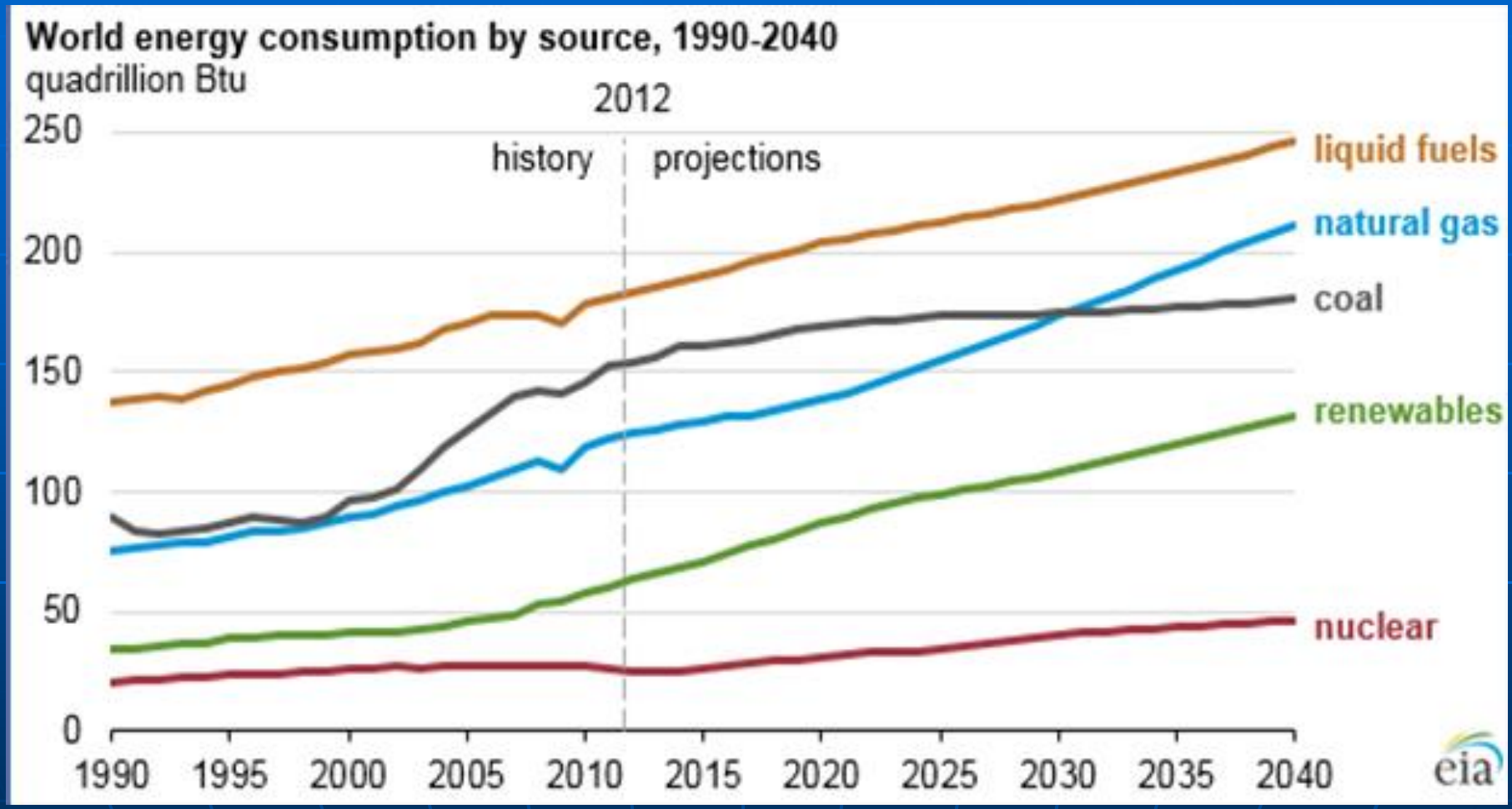
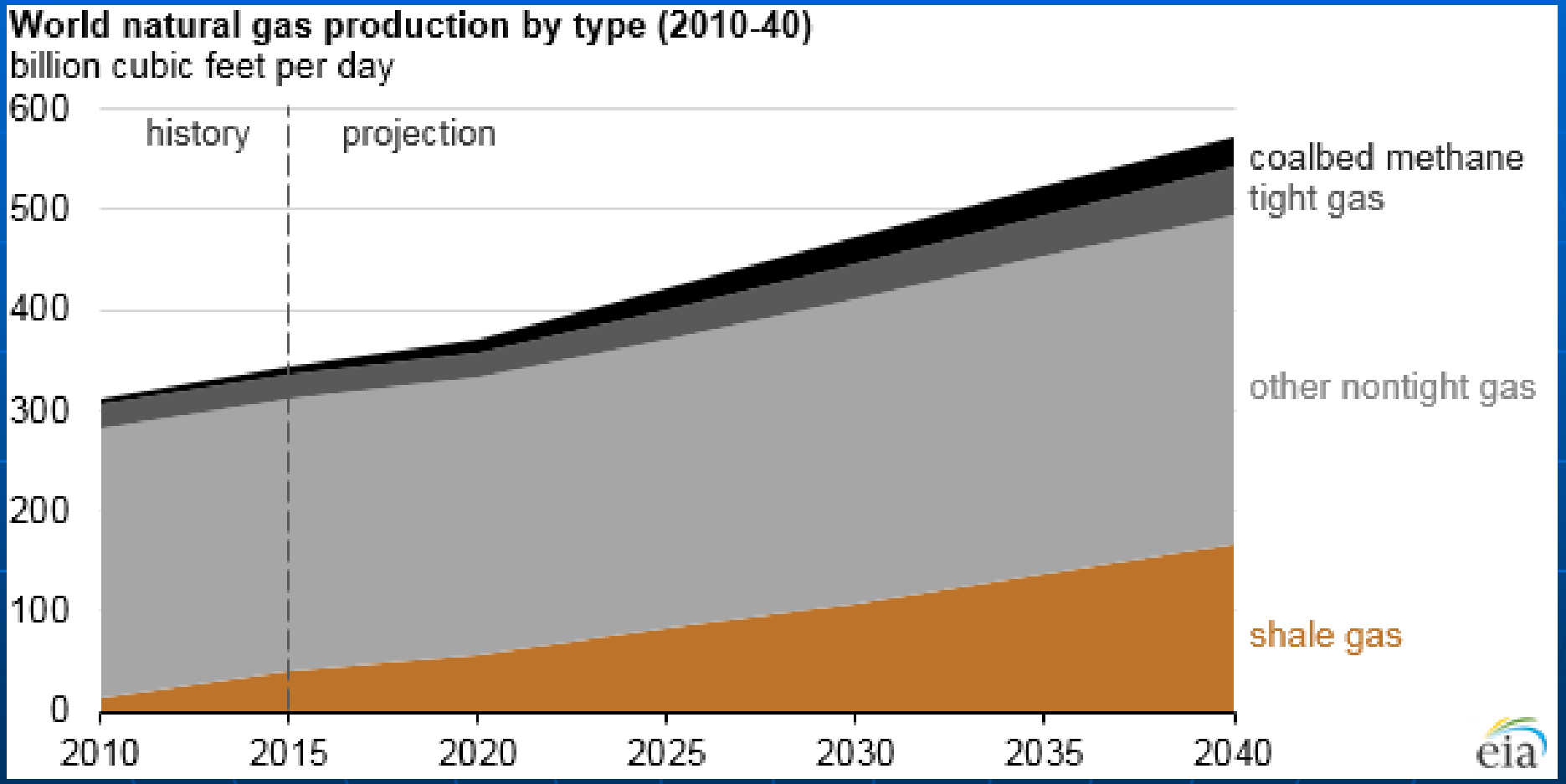
WHY?



Source: U.S. Energy Information Administration, *International Energy Outlook 2016* and *Annual Energy Outlook 2016*

WHY?



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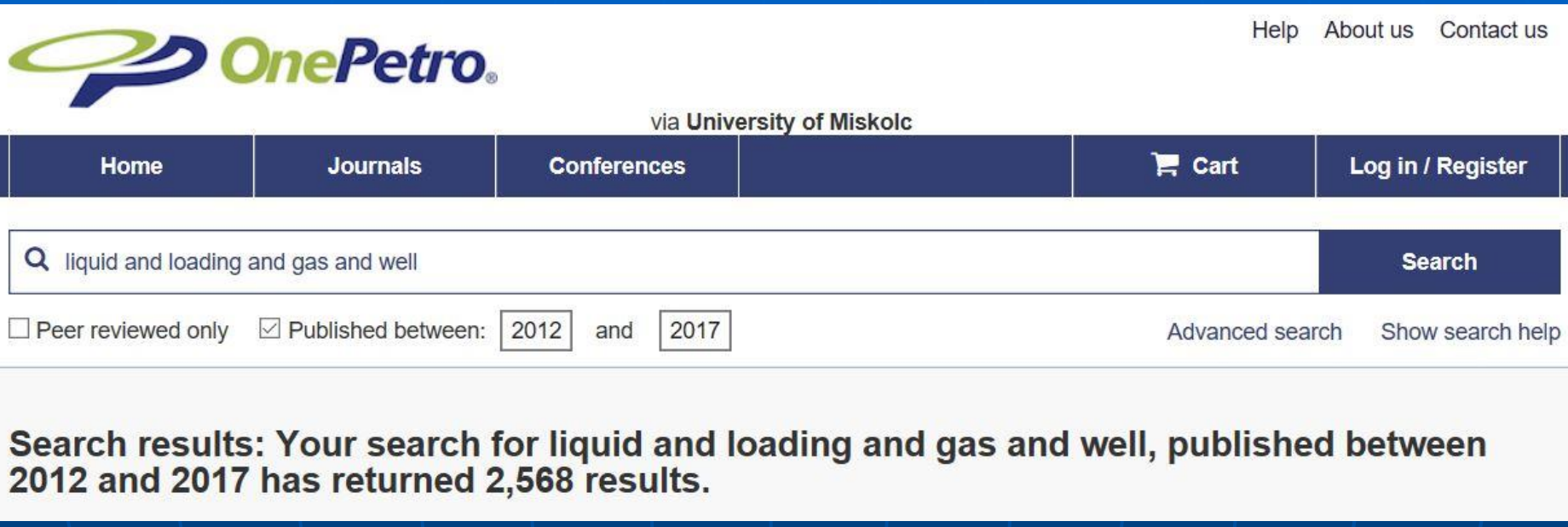
WHY?



Topic of them mostly:

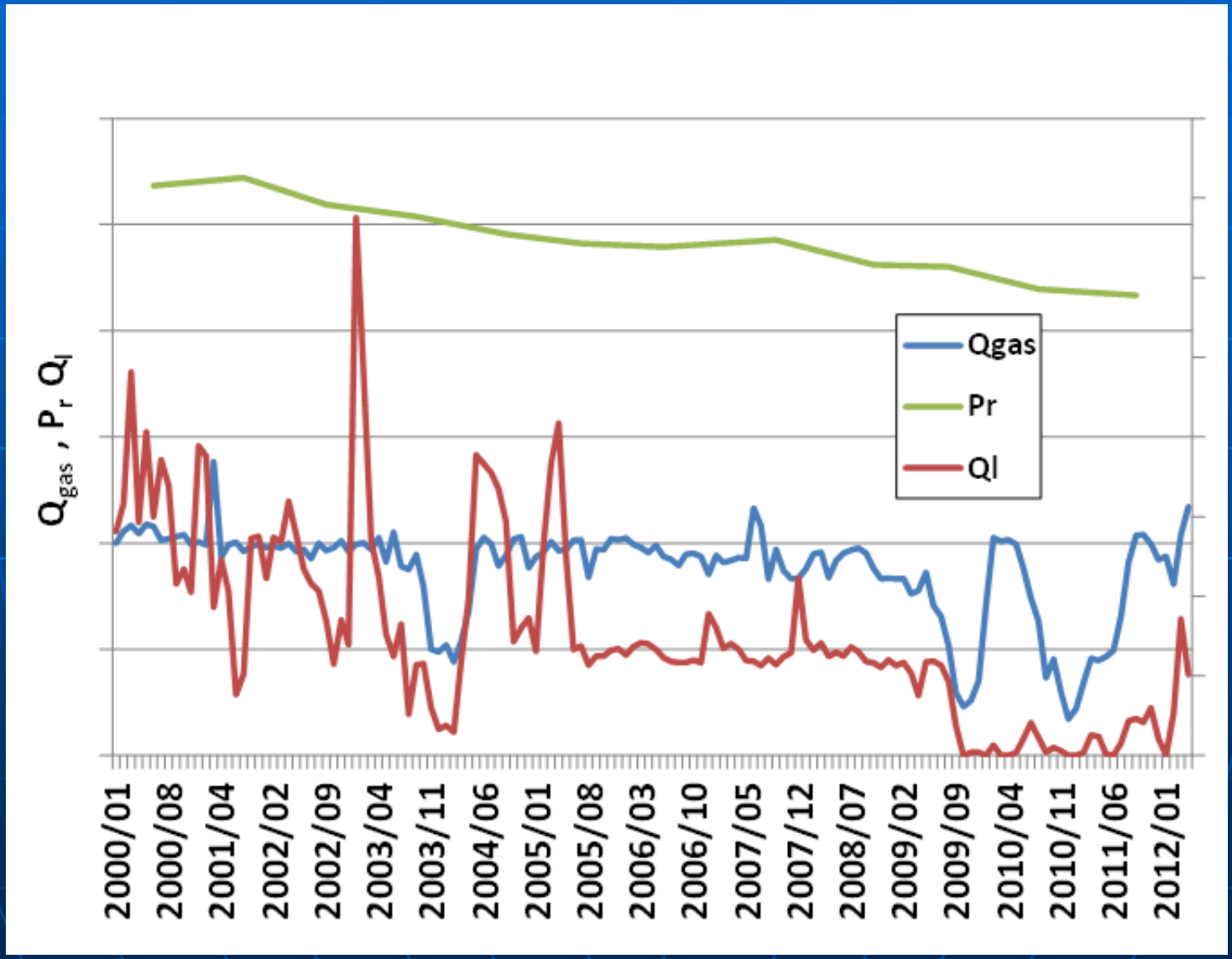
- **Recognition**
- **Modeling**
- **Case studies using well known methods**

FACTS OF LIQUID LOADING

Liquid in the gas stream

- **water, condensate**
- **critical velocity**
- **small amount enough**
- **increase FBHP**
- **self-generating effect**
- **decreased gas production**
- **decreased recovery (higher abandonment pressure)**

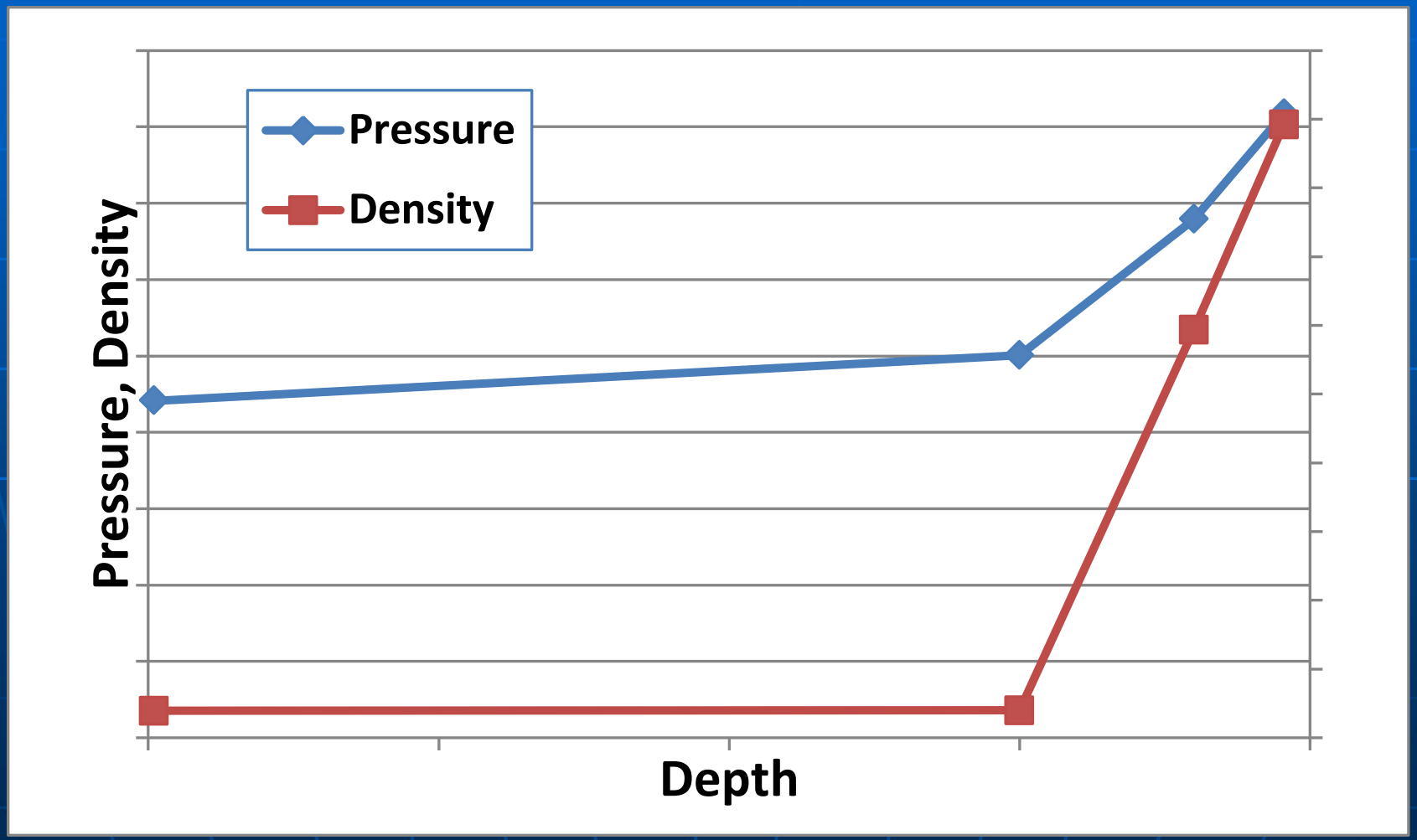
Recognition of fluid load



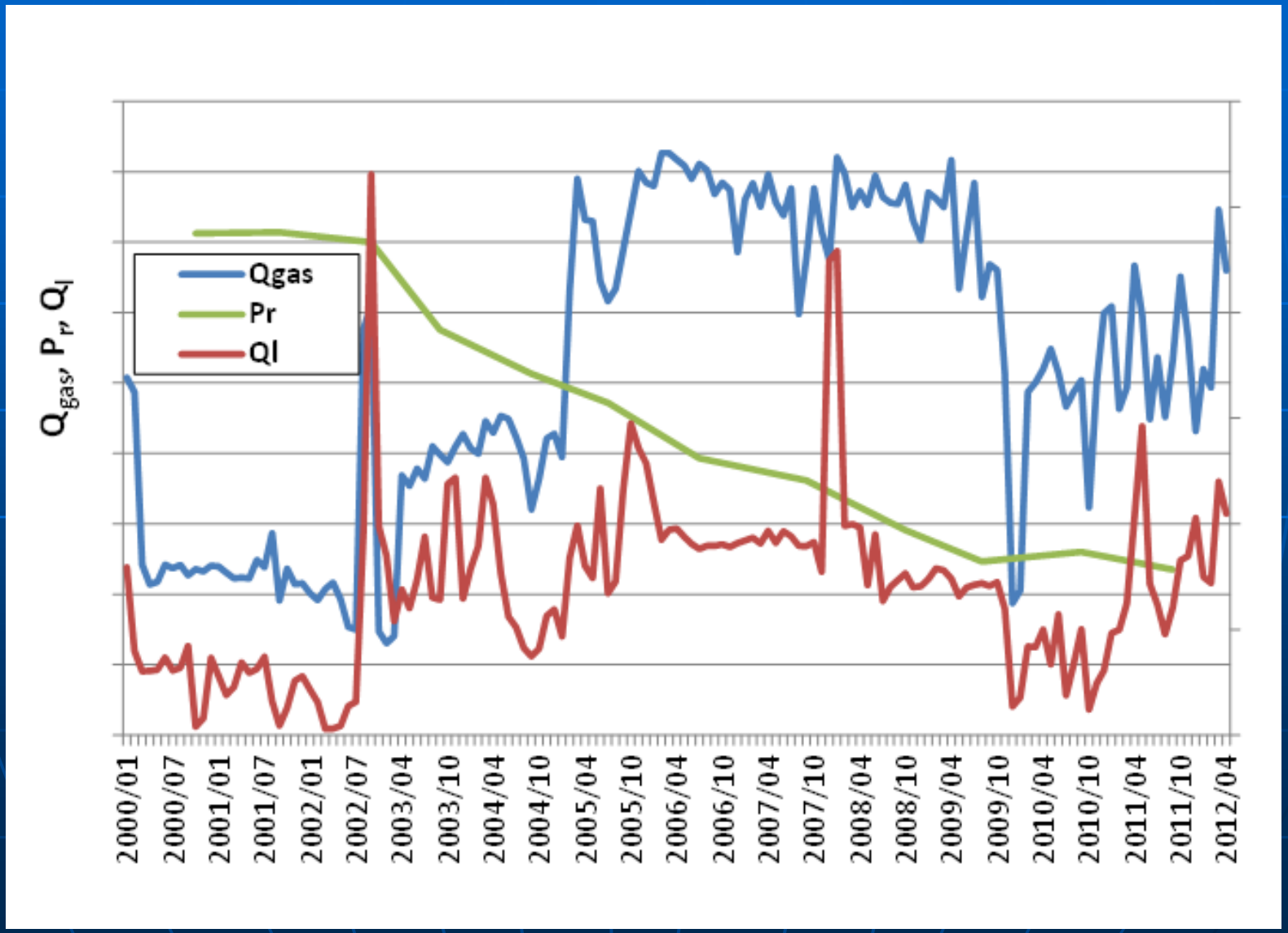
Recognition of fluid load „usual”

Date	Depth [m]	Pressure [Mpa]	Δl [m]	Δp [Mpa]	Density [kg/m^3]
4/9/2009	10	6.641			
	1500	7.572	1490	0.931	62.5
	1800	7.866	300	0.294	98.0
	1955	8.793	155	0.927	598.1
31/08/2010	10	4.411			
	1500	5.009	1490	0.598	40.1
	1800	6.789	300	1.78	593.3
	1955	8.172	155	1.383	892.3

Recognition of fluid load „usual”



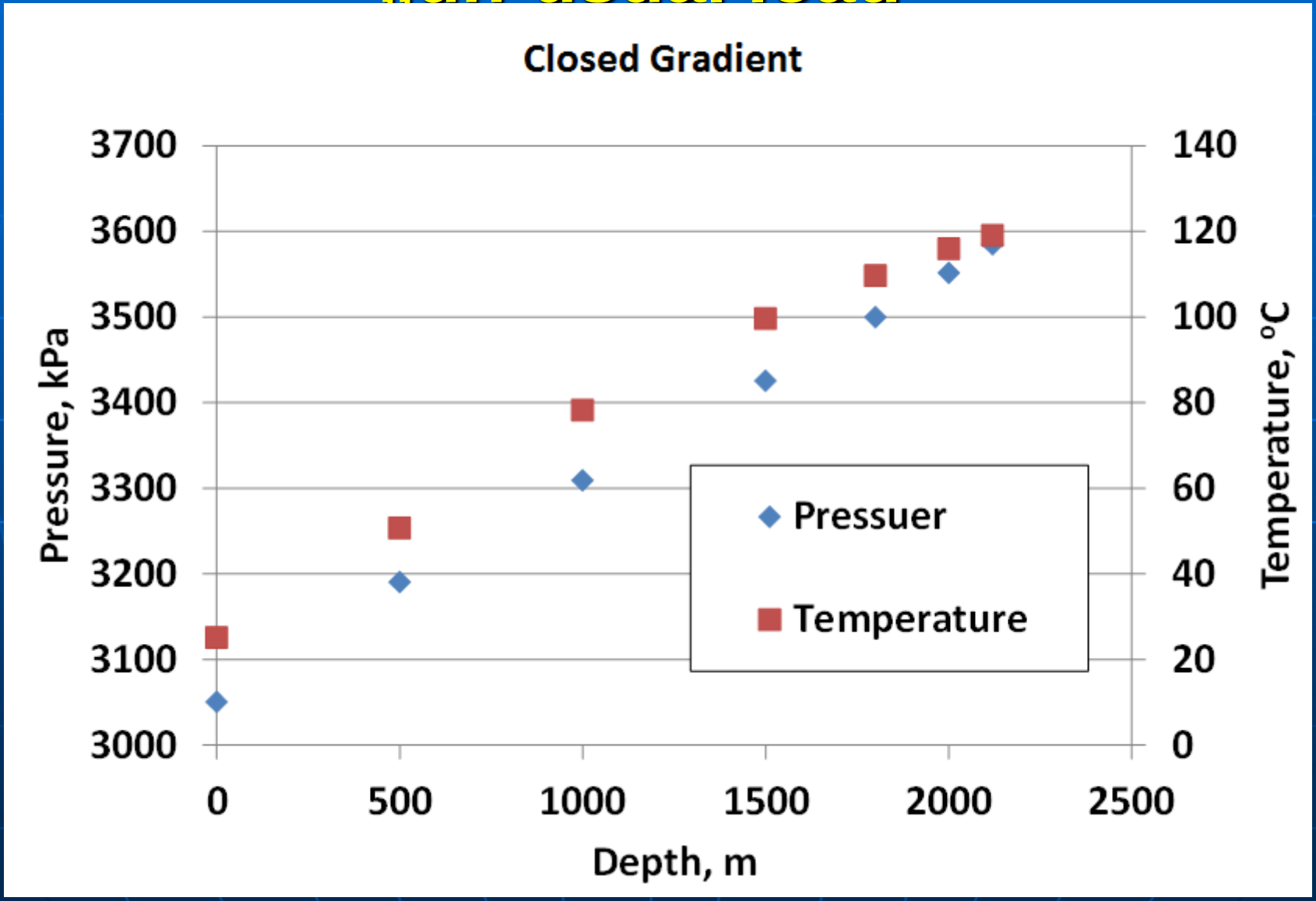
Recognition of fluid load „un-usual”



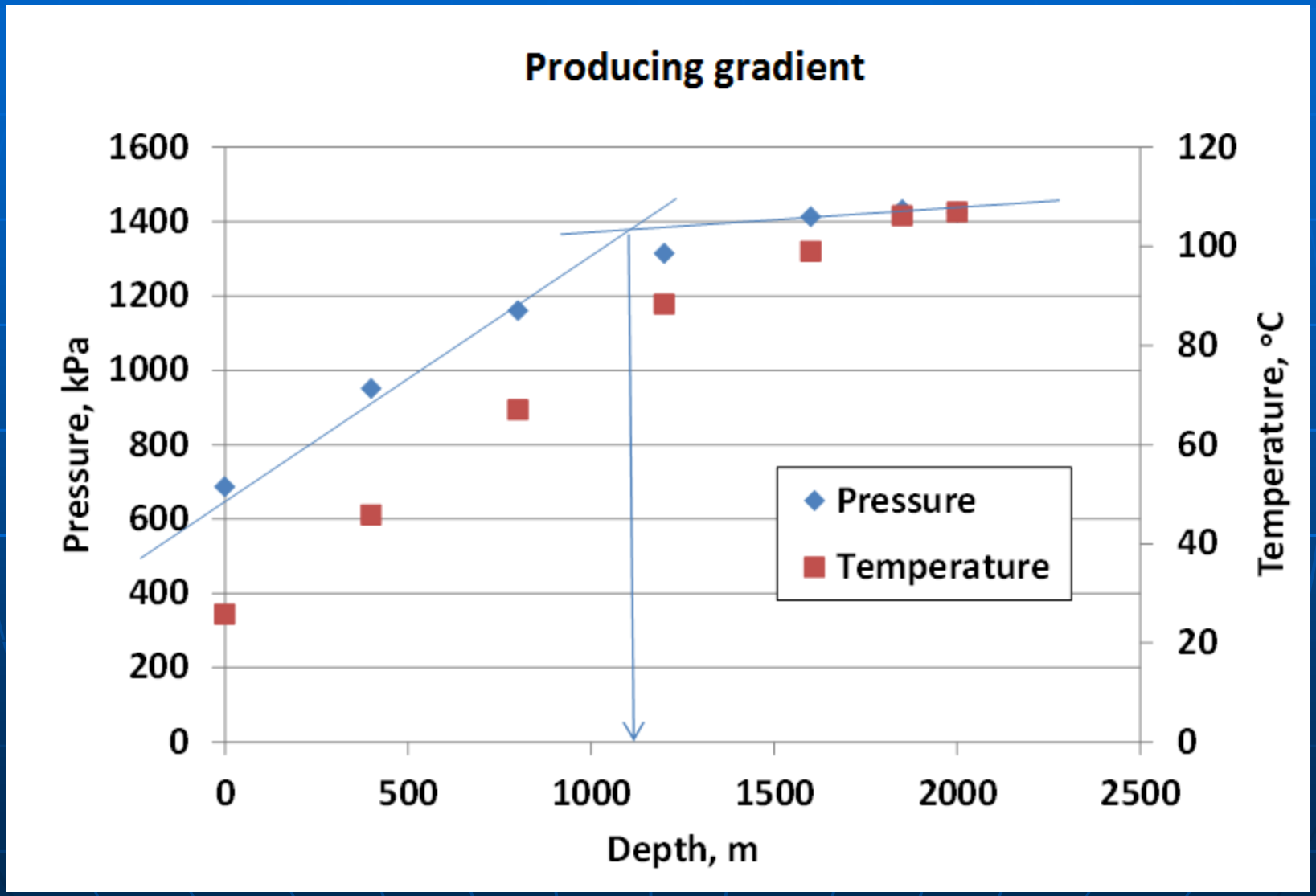
Recognition of fluid load „un-usual”

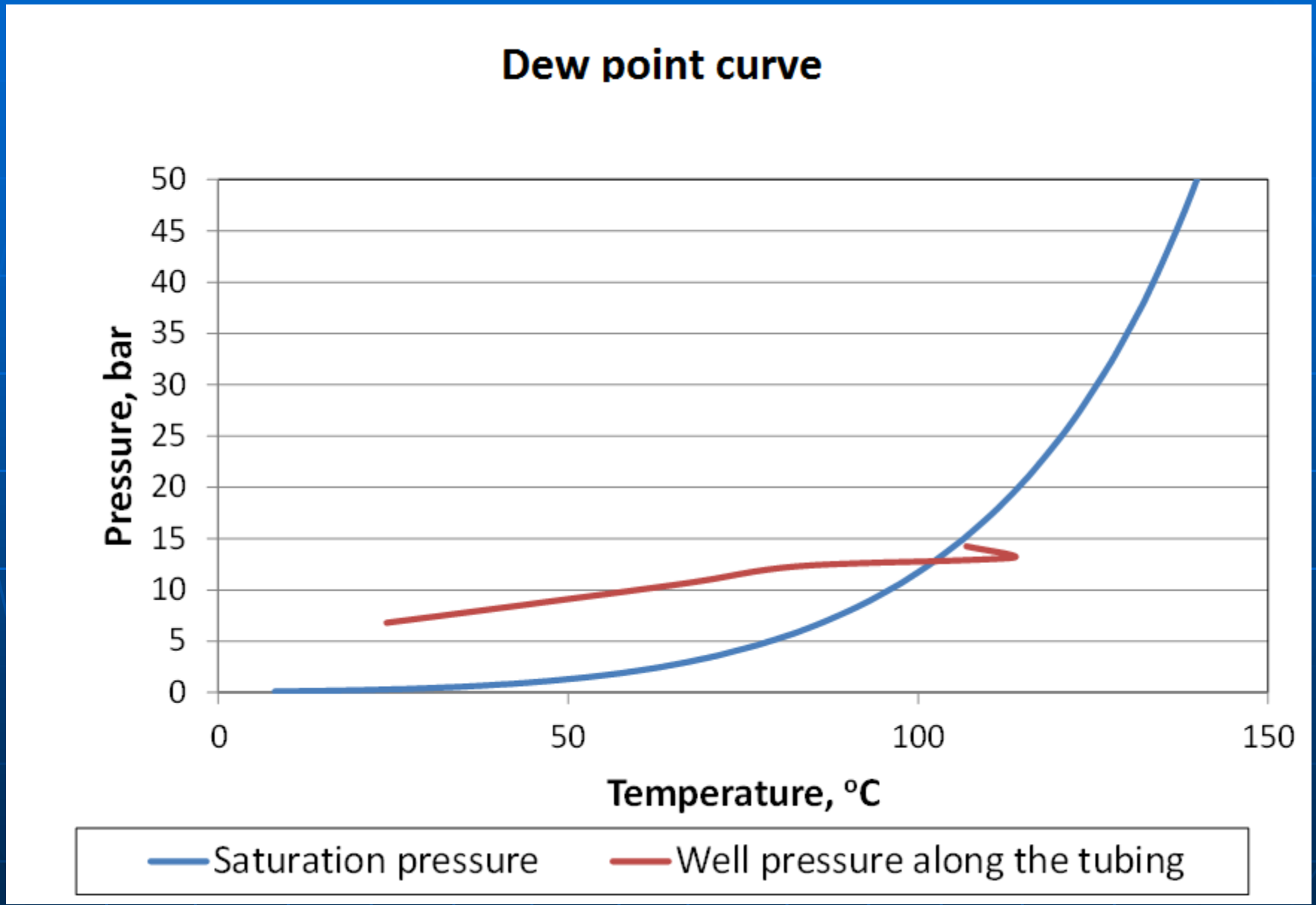
Date	Depth [m]	Pressure [Mpa]	Δl [m]	Δp [Mpa]	Density [kg/m^3]
1/9/2010	10	4.405			
	1000	4.796	990	0.391	40.3
	1900	5.107	900	0.311	35.2
	2060	5.17	160	0.063	40.1
28/09/2011	10	3.996			
	1000	4.332	990	0.336	34.6
	1900	4.617	900	0.285	32.3
	2060	4.673	160	0.056	35.7

Gradient measurements „un-usual load”



Gradient measurements „un-usual load”




Dew point curve
Pressure, bar
50
45
40
35
30
25
20
15
10
5
0
0
50
100
150
Temperature, °C
Saturation pressure
Well pressure along the tubing

MODELING

Transient nature of loading process:

- **correlations,**
- **analytical,**
- **numerical.**

Help to understand, to identify, to predict!

Important, but not enough!

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CASE STUDIES USING WELL KNOWN METHODS

- Sizing Tubing
- Compression (reduced WHP)
- Plunger Lift
- Foam
- Hydraulic Pumps
- Beam Pumps
- Gas Lift
- ESP
- PCP
- Thermal methods
- Cycling

CONTINUOUS REMOVAL OF LIQUID

- Tubing sizing
- Compression
- Foam
- Thermal methods

Prevent liquid accumulation

Keep FBHP constant

Requires relativly higher rates or pressure

INTERMITTENT METHODS

Problem:

- **FBHP increasing during liquid accumulation**

Group 1

- **Hydraulic Pumps**
- **Beam Pumps**
- **Gas Lift**
- **ESP**
- **PCP**

Group 2

- **Cycling**
- **Plunger Lift**

INTERMITTENT METHODS

- **Group 1 – Expensive!**
- **Group 2 – Cheaper methods!**

- **Periodic liquid load, higher abandonment pressure!**

IMPROVED METHODS

Goals:

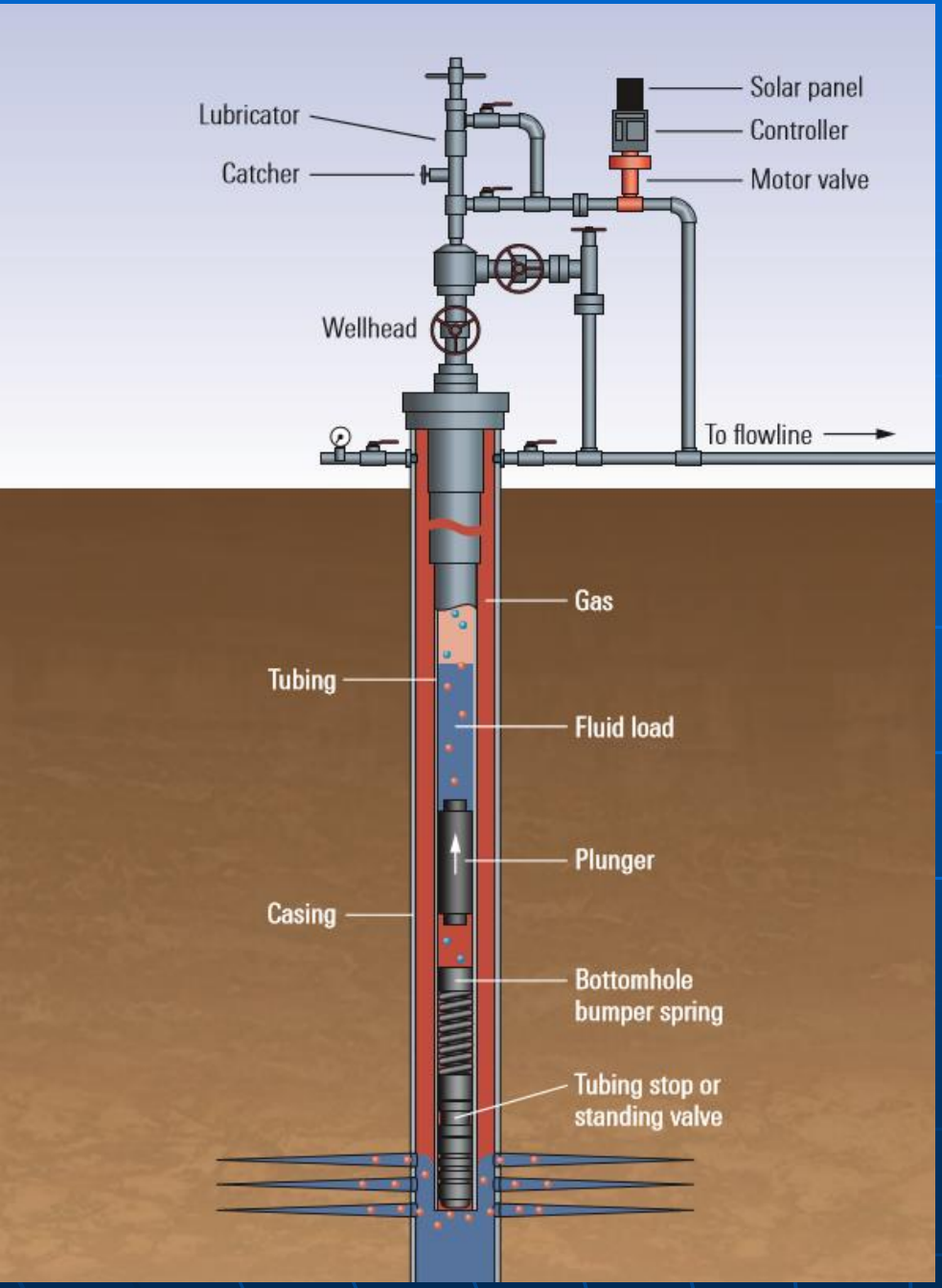
Avoid liquid accumulation on formation

- **extend applicable pressure and rate ranges**

Keep it as cheap as possible:

- **simple**
- **small unit cost**
- **no external energy**

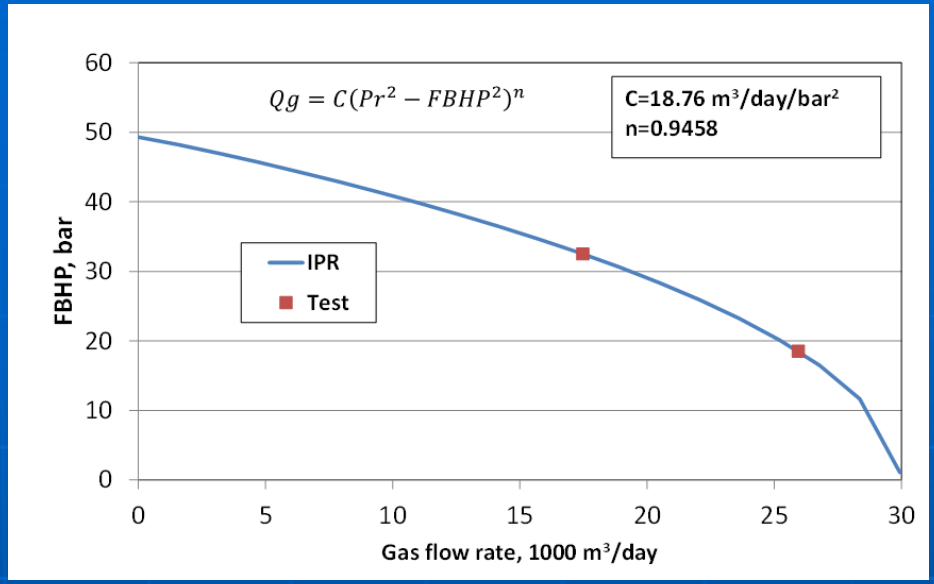
Conventional Plunger Lift System



Source: Schlumberger, Oilfield Review, 2016
http://www.slb.com/-/media/Files/resources/oilfield_review/defining_series/Defining-Plunger-Lift.pdf?la=en&hash=5F6DB67DA02692B276CB493EFD1693BA23E2E754

For usual loading

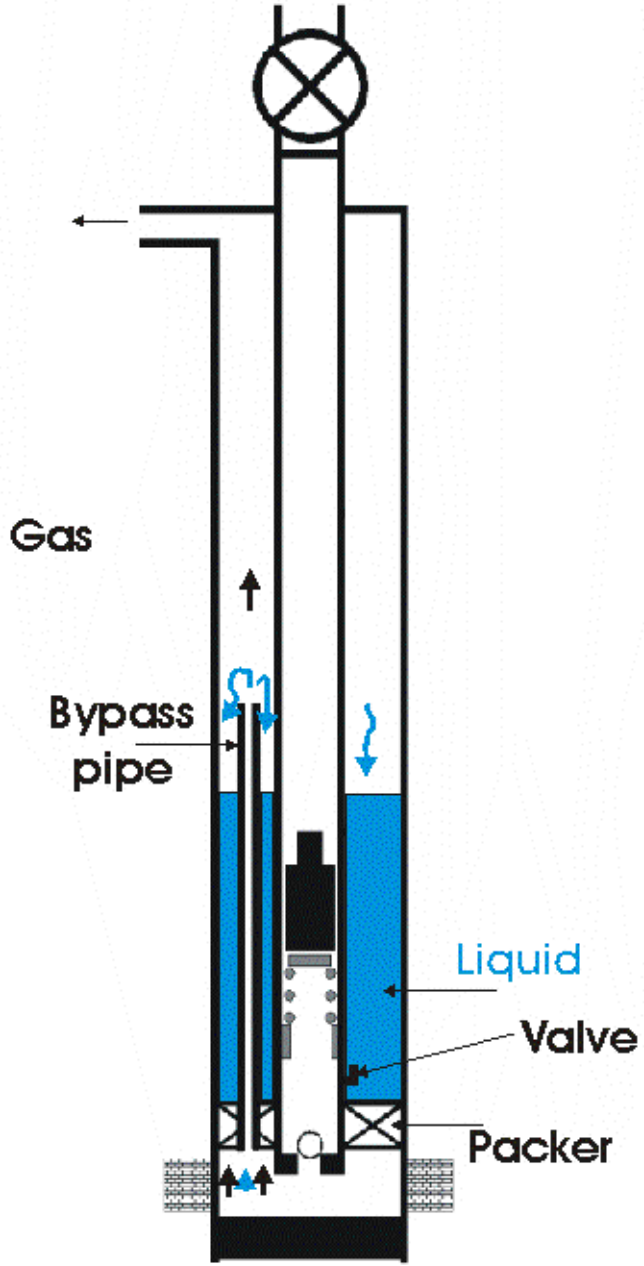
Pr ~ 50 bar
L = 2000 m
dc = 7 in
dt = 3.5 in
Qg ~ 26 000 m³/d
Qw ~ 8 m³/d



Calculated Plunger Lift parameters (Foss and Gaul)
Pcmin = 7,8 bar
Pcmax = 10,2 bar
Qw = 8,6 m³/d
Qg req = 1400 m³/d

Theoretically:
Until Pr > ~12-14 bar the well can be plunger lifted!

„IMPROVED" PLUNGER LIFT

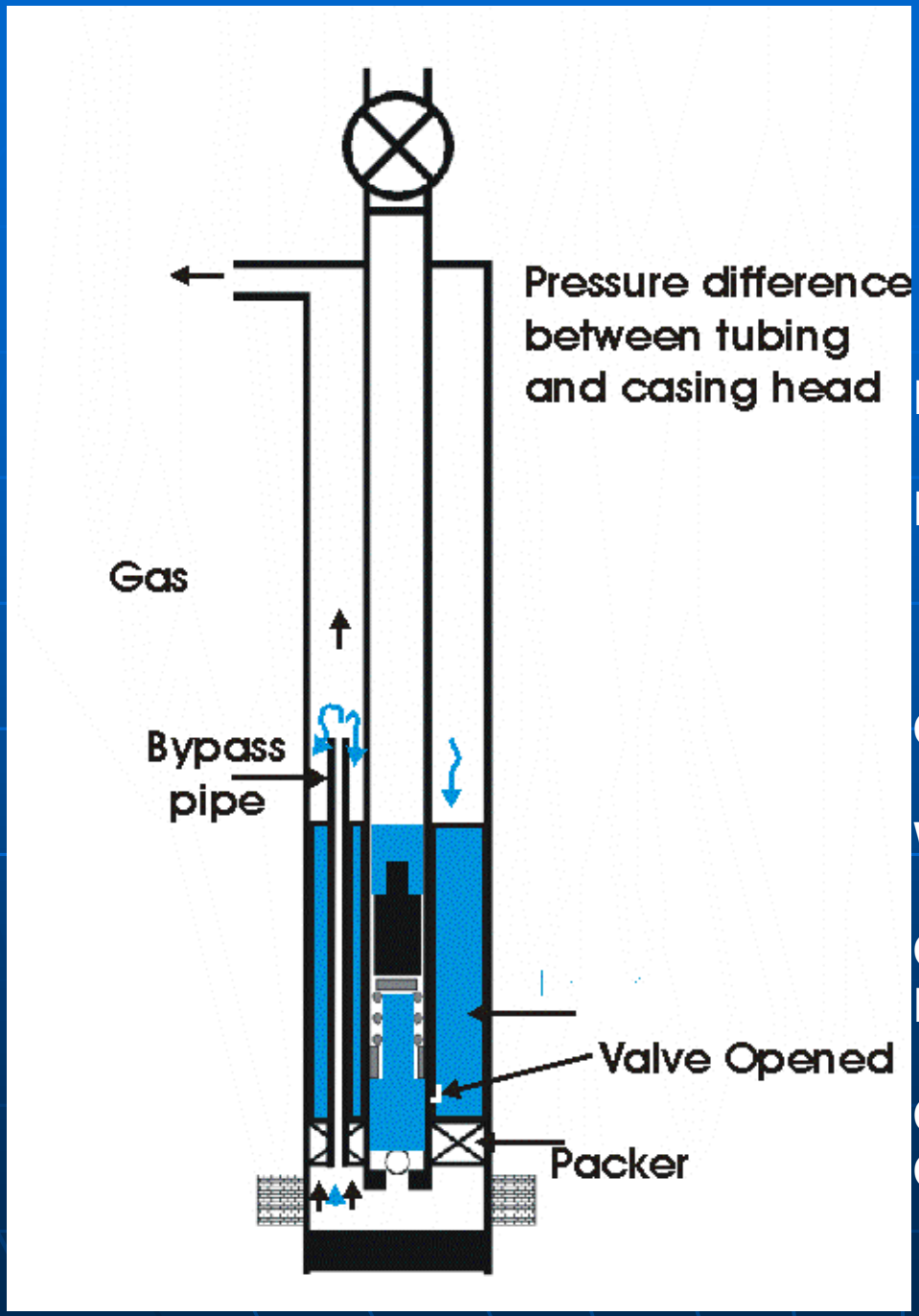


Bypass pipe

Production through annulus
Increasing Liquid Level in Annulus
No backpressure!

Valve or Level control
Opened at prescribed liquid level

„IMPROVED" PLUNGER LIFT



Liquid pressed to tubing

Pressure difference formed

Pt N Pc

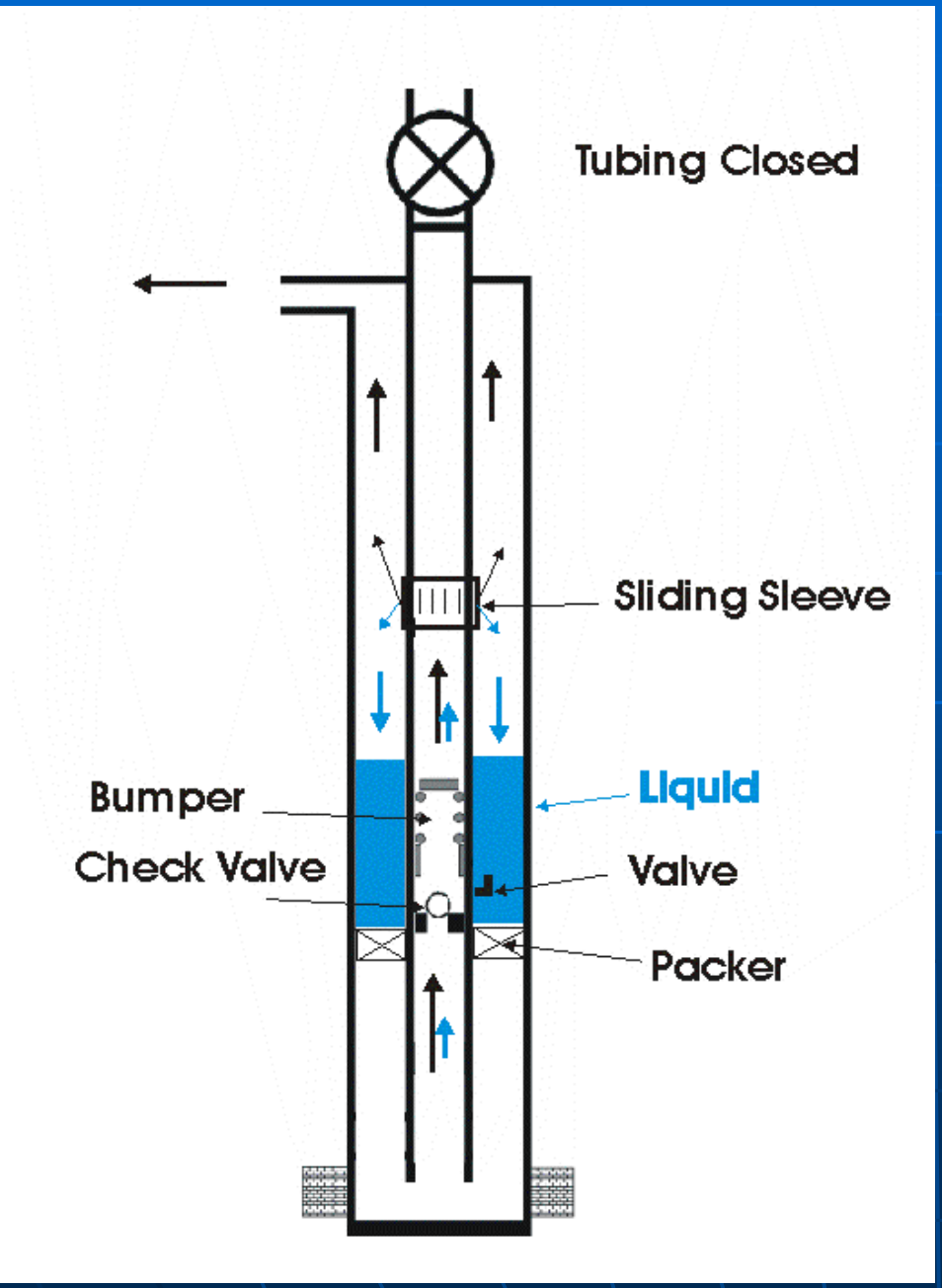
Close the casing

Wait for req. pressure build up

Open tubing
Plunger and liquid surfaced

Close tubing
Open casing

„IMPROVED" PLUNGER LIFT „UNUSUAL"



Sliding sleeve

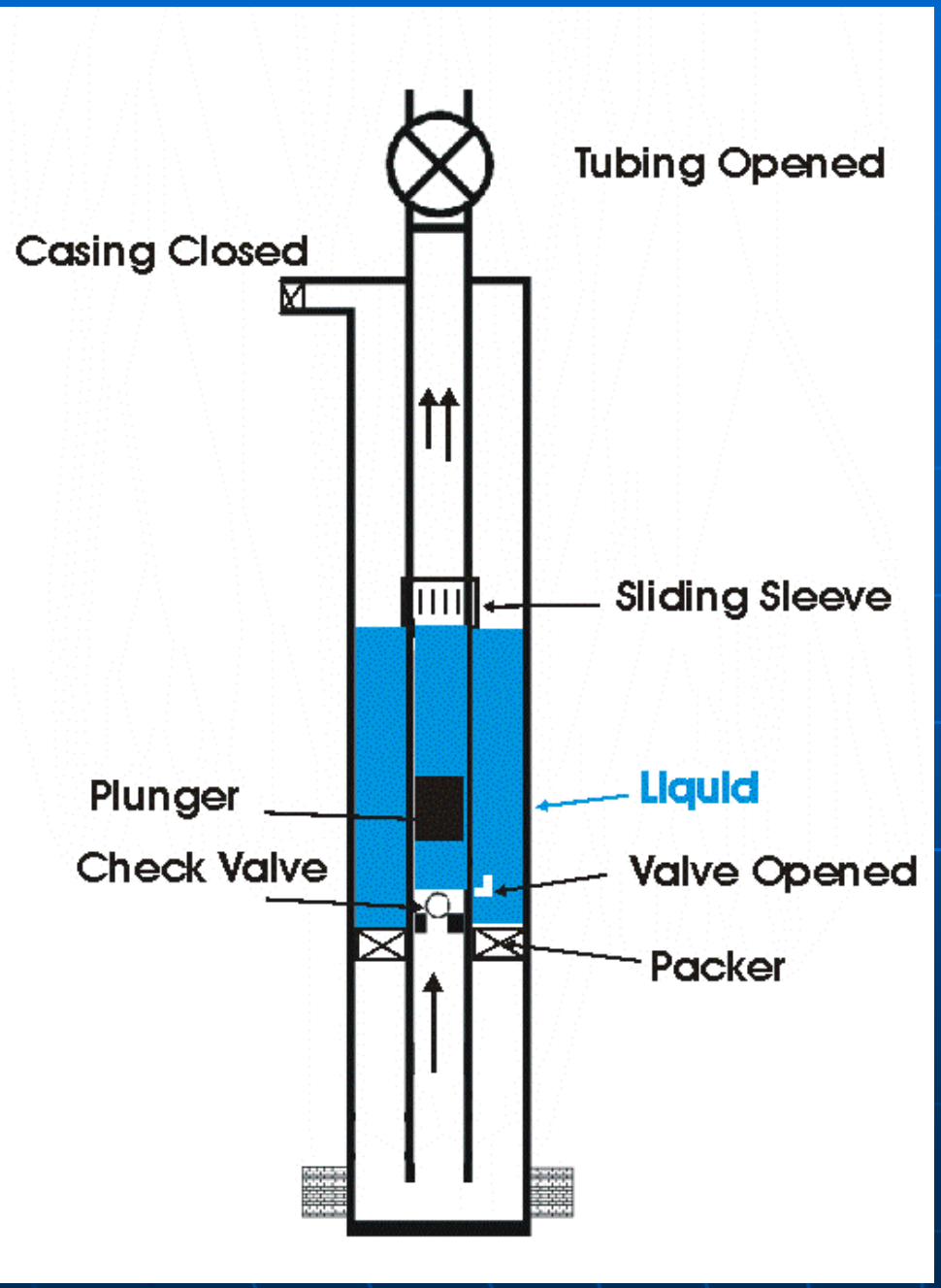
Production through tubing to annulus

Increasing Liquid Level in Annulus
No backpressure!

Valve and Level control
Signal to Surface at prescribed liquid level

Close casing
Wait for pressure buildup

Valve Opened at prescribed pressure
Liquid equalised to tubing



„IMPROVED" PLUNGER LIFT „UNUSUAL"

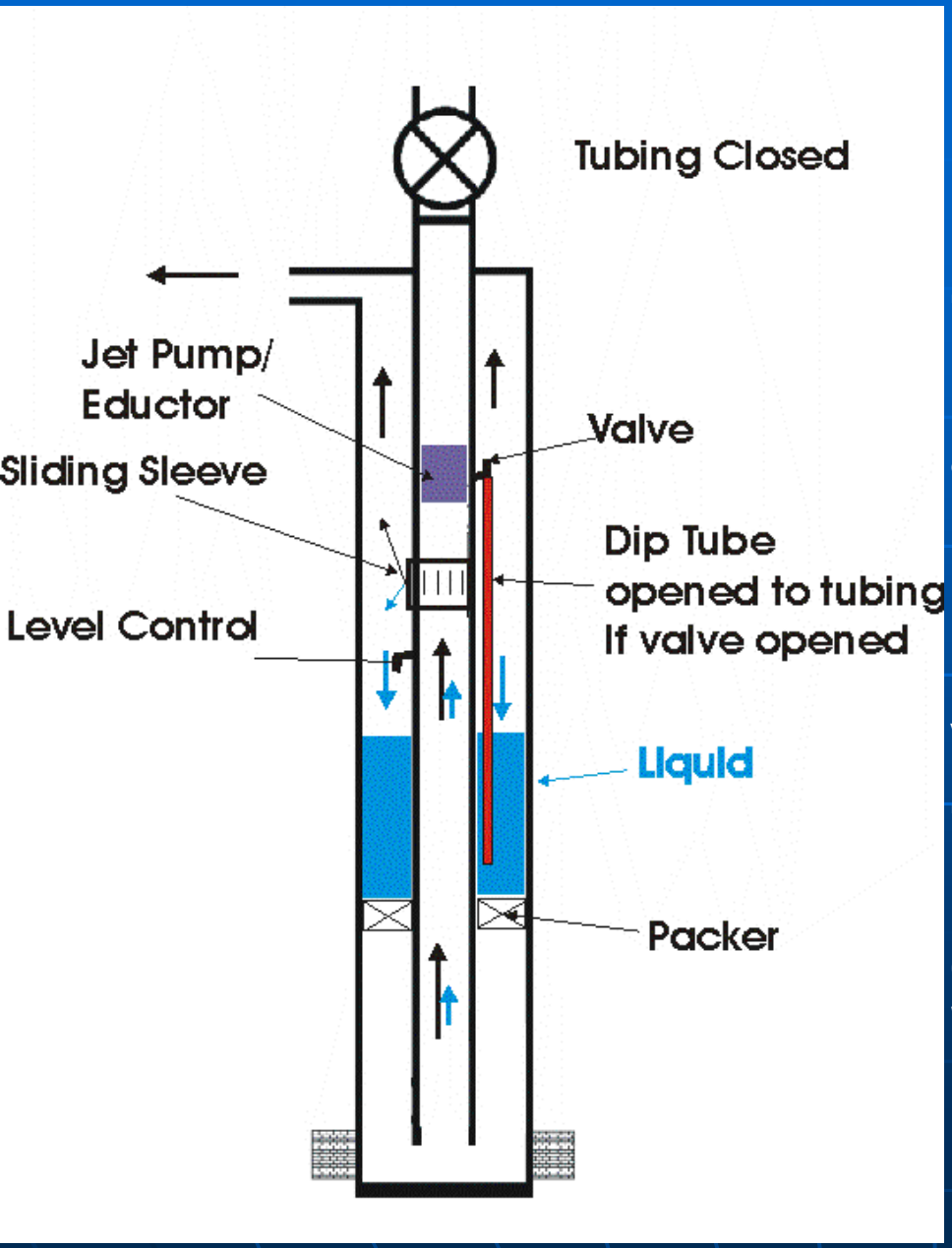
Plunger to the bumper

Open Tubing

Liquid and plunger to the surface

Smaller depth, smaller req. pressure

JET PUMP „UNUSUAL”



Sliding sleeve

Production through tubing to annulus

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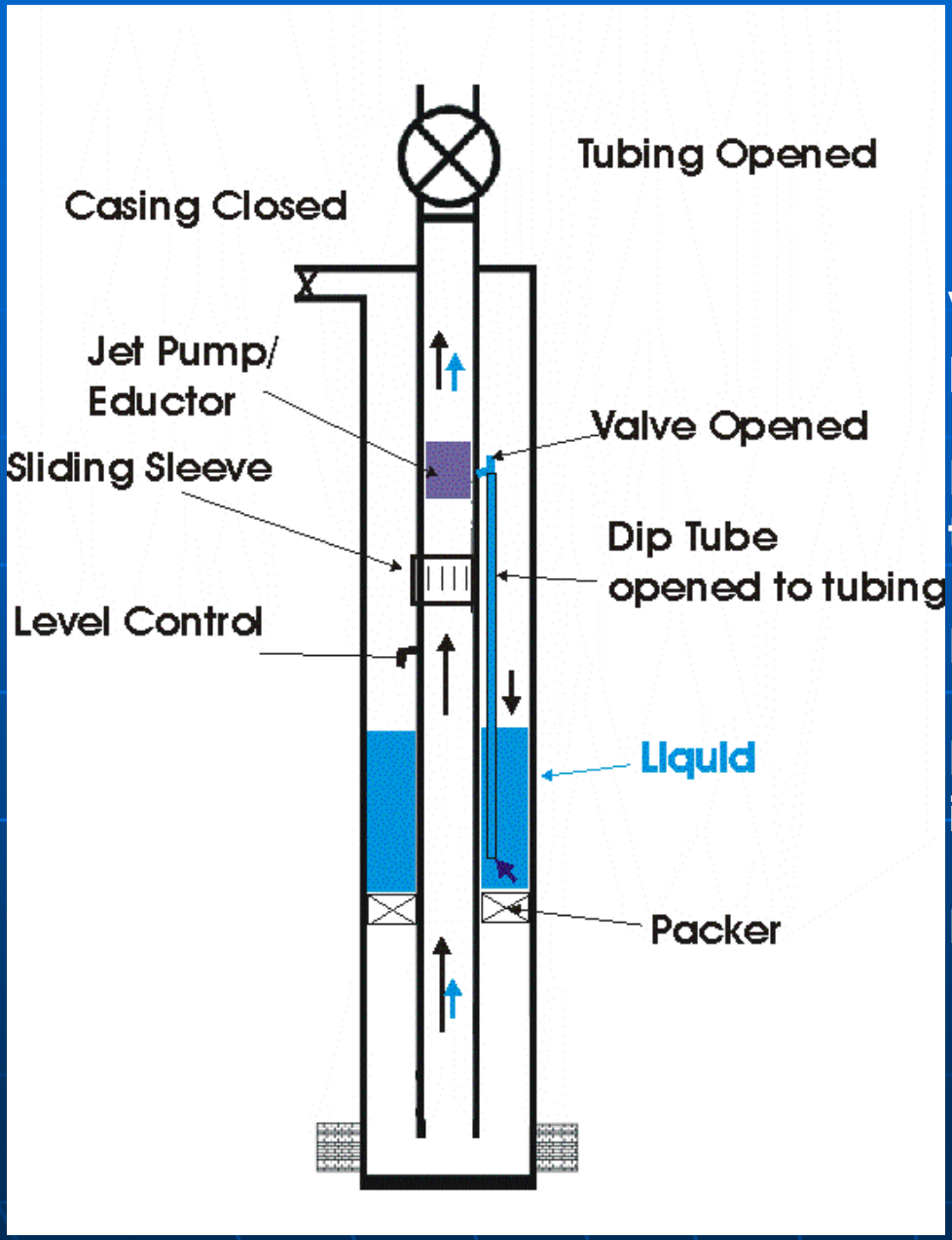
Signal to Surface at prescribed liquid level

Close casing
Wait for pressure buildup

JET PUMP „UNUSUAL”



Valve and tubing is opened at prescribed pressure

Liquid is pressued to Jet Pump through Dip Tube

Powerfluid is the accumulated gas

Liquid transported to the surface in small droplets

No moving Parts

CONCLUSIONS

Selection of the right unloading method is critical!

Advantages:

- **Simple**
- **Low cost equipment**
- **No external energy required**

Possible Good Choices

- **Plunger Lift**
  - **Conventional**
  - **Improved**
  - **For unusual liquid loads**
- **Jet Pump with Produced Gas as Power Fluid**

THANK YOU
FOR YOU ATTENTION!