Distinguished Lecturer Program

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Distinguished Lecturer Program

Ways to Successfully Reduce Well Blowout Events

Otto Luiz Alcantara Santos

Petróleo Brasileiro S.A. - Petrobras

Society of Petroleum Engineers
Distinguished Lecturer Program
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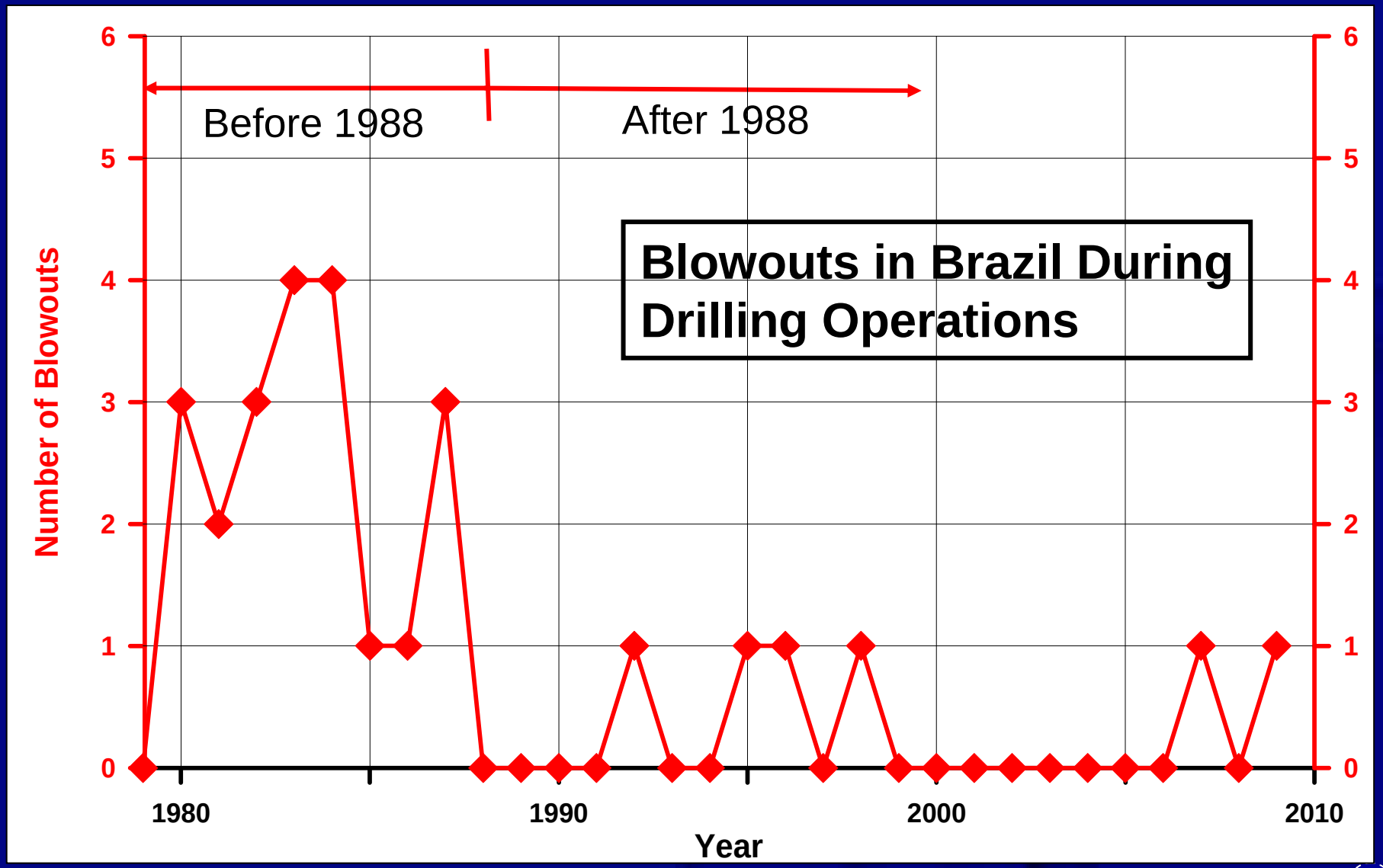
Motivation for the Lecture



Lecture Objective

To show how a major oil company can act to preserve its personnel, assets and image from the consequences of a well blowout in drilling and production operations

Presentation Outline

- **Introduction**
- **Well Control Training and Certification Program**
- **Well Control in Drilling and Production Operations**
- **Well Control in Deep and Ultra-Deep Waters**
- **Research and Development in Well Control in Ultra-Deep Waters**
- **Conclusions**

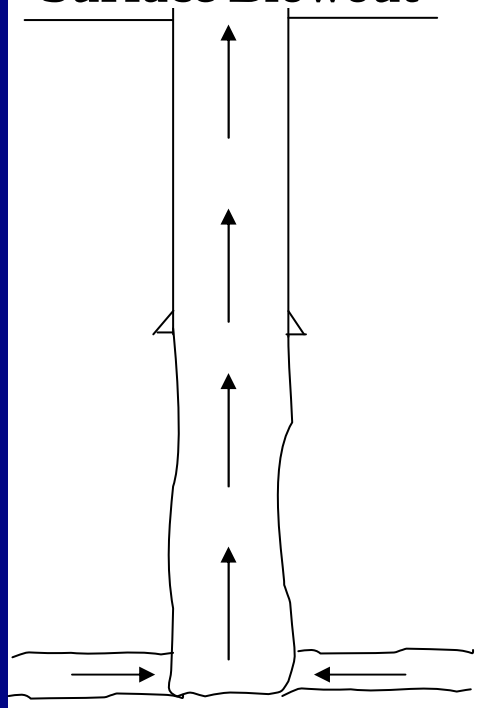
Kicks and *Blowouts Definitions*

- **Kicks – Undesirable flow from the formation into the well that happens when the pressure inside the well becomes less than the pressure of that formation.**

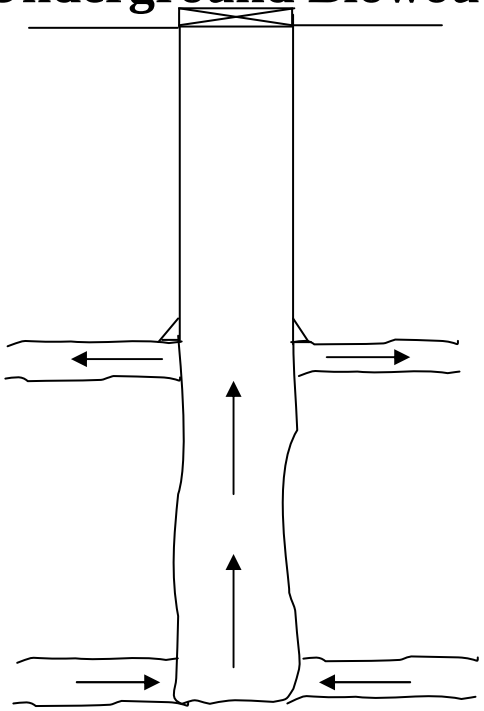
- **Blowouts – Uncontrolled flow from the formation into the well and then to the atmosphere, sea bottom or other uncased formations.**

Blowouts Classification

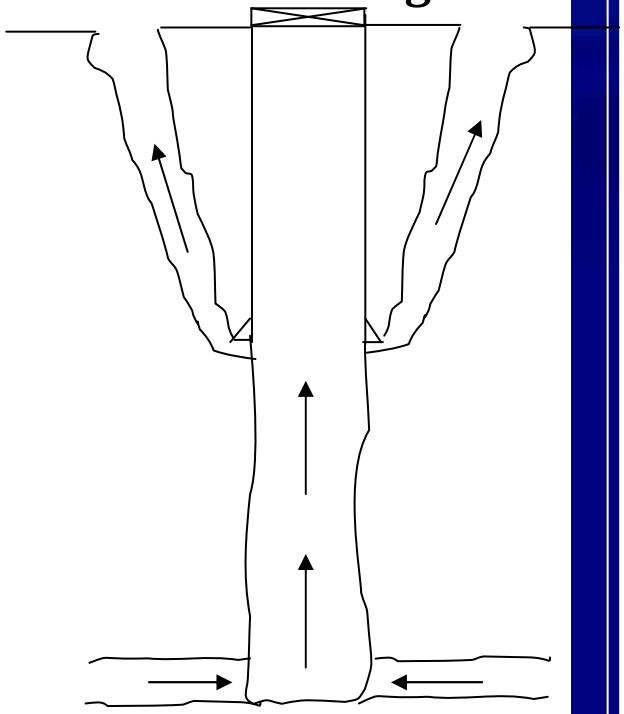
Surface Blowout



Underground Blowout



Cratering

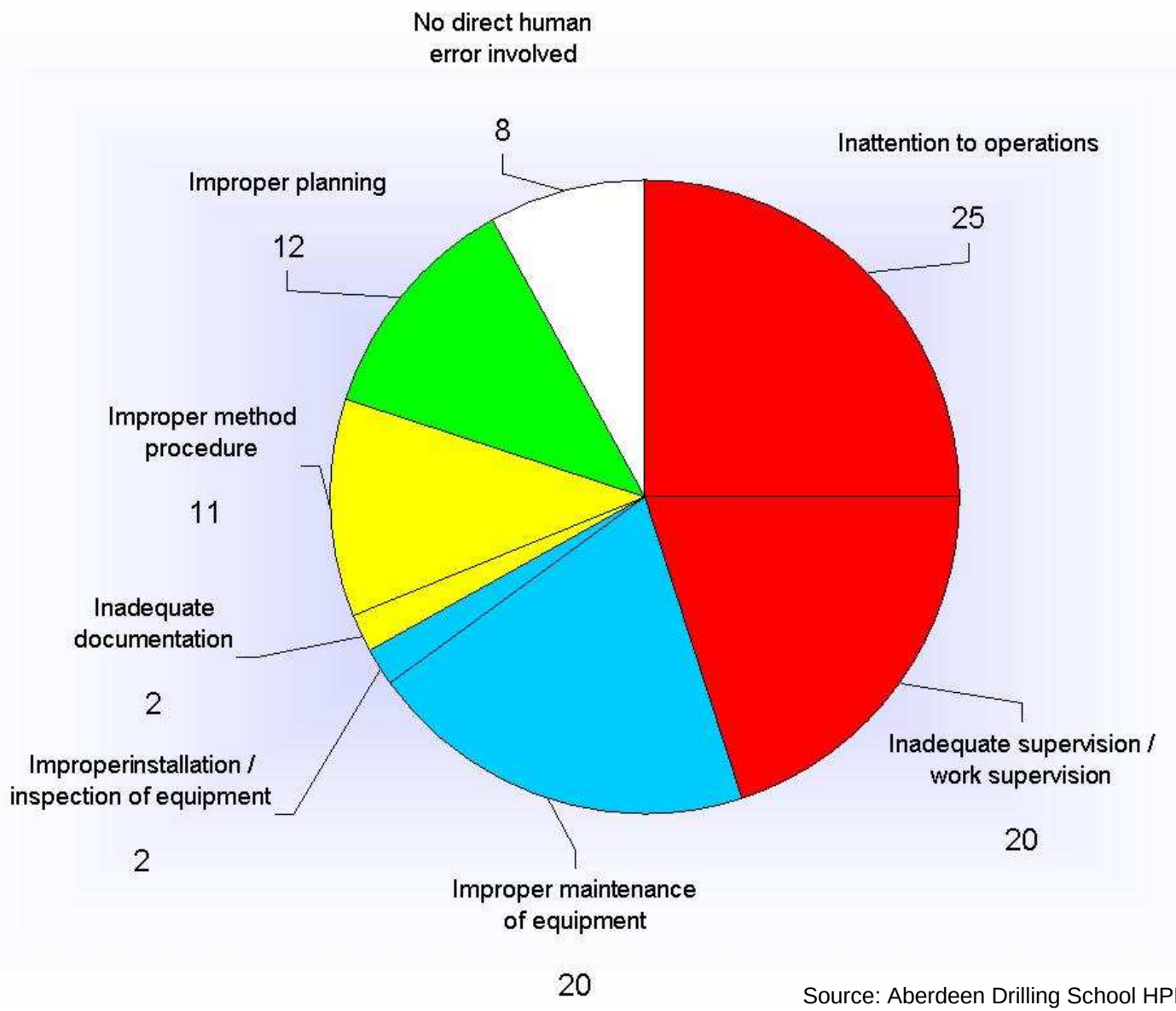


Examples of Blowouts

Consequences of a Blowout

- **Loss of Human Lives**
- **Loss of Reserves**
- **Loss of Equipment**
- **Production Discontinued**
- **Environmental Aggression**

Human Factors Review for Offshore Blowouts



Source: Aberdeen Drilling School HPHT Manual

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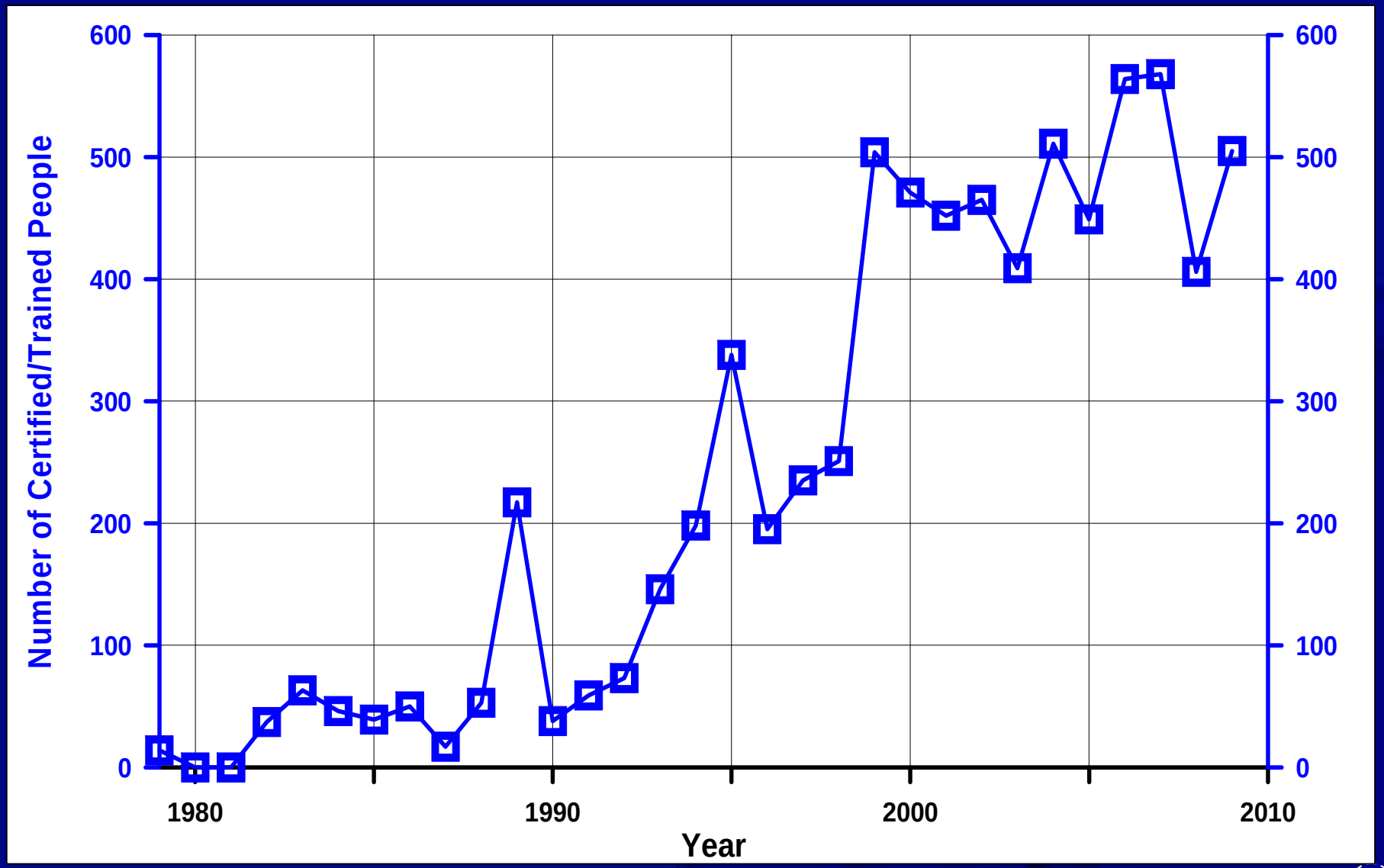
Certification and Training Program in Well Control

- **Well control training starts in 1971**
- **In 1993, the Well Control Certification and Training Program is created and conducted by Petrobras University**
- **The program is accredited by WellCAP of IADC in July, 1996**

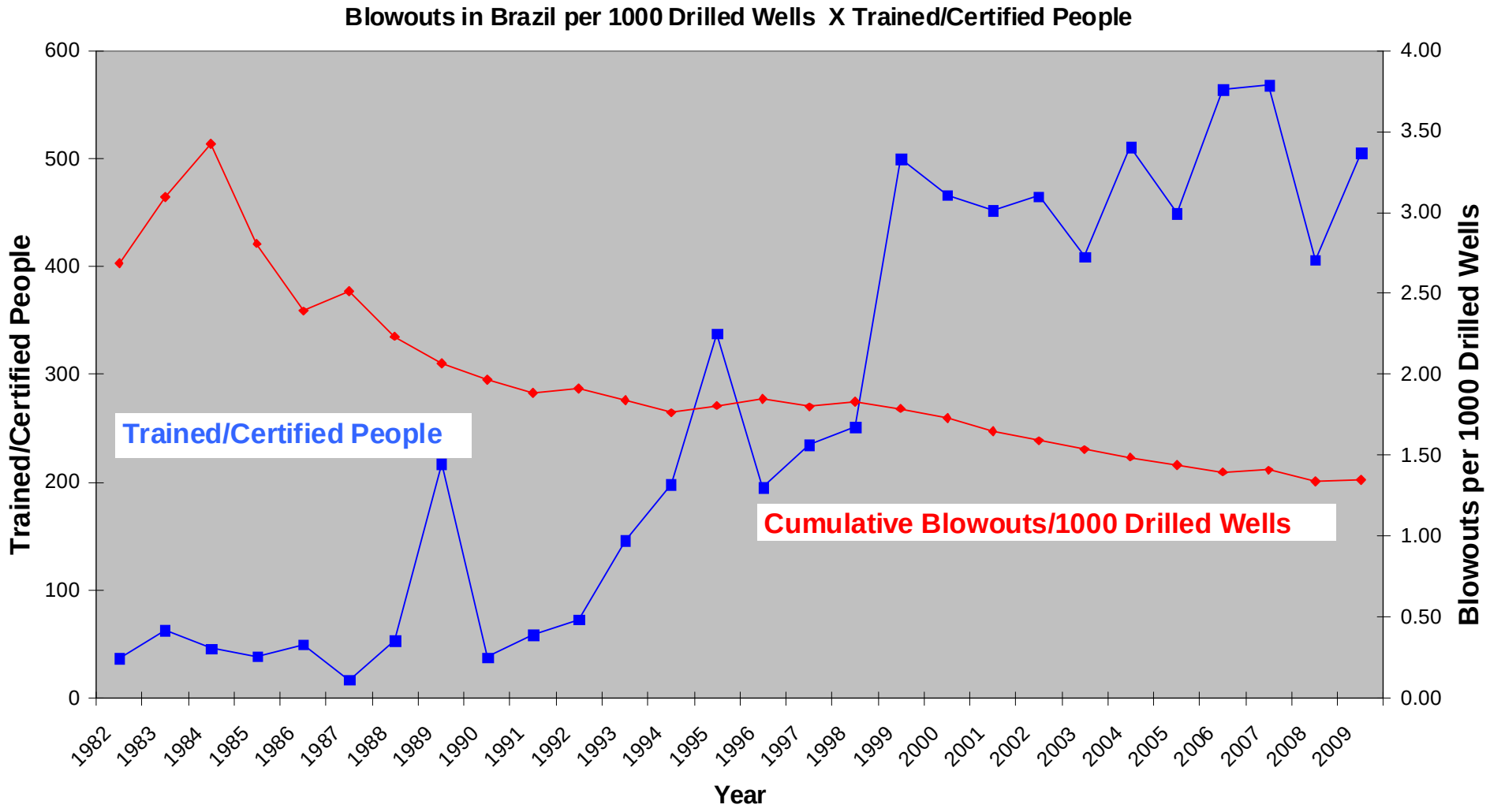
WellCAP Certificates Issued Until 31 December, 2009

LEVEL	INTRODUCTORY	FUNDAMENTAL	SUPERVISION	TOTAL
SURFACE	1006	974	1194	3174
COMBINED (SURFACE/ SUBSEA)	266	494	2003	2763
TOTAL	1272	1468	3197	5937

Trained/Certified People



Cumulative Blowouts in Brazil per 1000 Drilled Wells



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Personnel (Well Control Team)

- Monitoring of well control certificates
- Drills at the rig site

Well Control Equipment (Well Control Team)

- Rig inspections upon receiving it
- Monitoring of well control equipment and kick detection tests

Development of Well Safety Standards

- Creation of a committee to review, elaborate and approve internal well safety standards
- There are 17 standards approved and in use

Operations (Well Control Team)

- Elaboration and approval of operational procedures especially in deep waters
- Reinforcement of the use of these operational well safety procedures and standards

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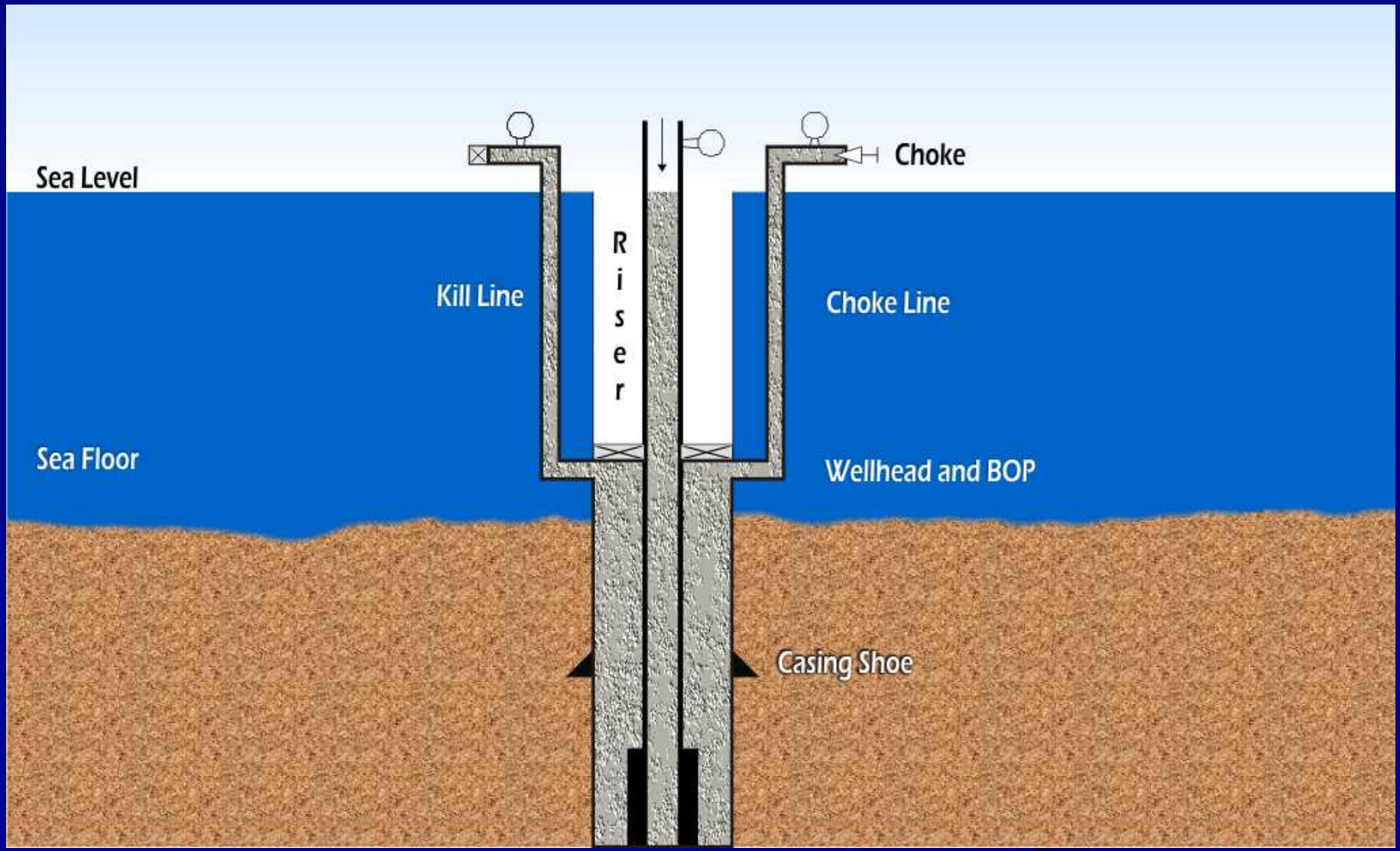
Peculiarities of deepwater and ultra-deepwater well control

- **Low fracture gradients**
- **Excessive frictional pressure inside the choke line**
- **Low temperatures**
- **Hydrate formation**
- **Gas in riser**

Subsea Configuration



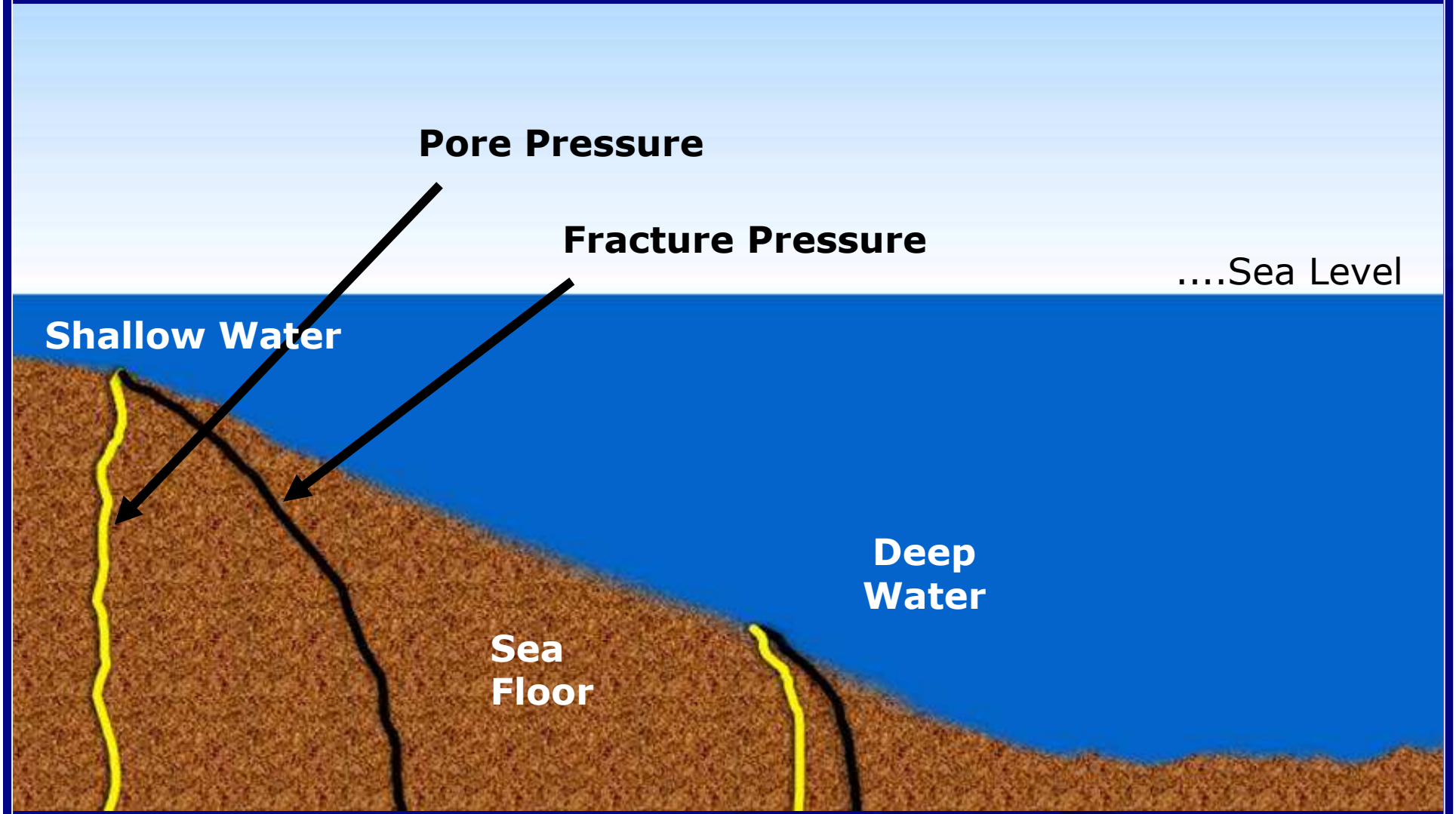
Low Fracture Gradients

- **Fracture pressures in deep waters are lower than those found onshore or in shallow waters**
- **The overburden pressure is lower due the seawater**
- **Narrow operational window for the mud weight**

Low Fracture Pressure

Well	Shoe Depth (m)	Water Dept (m)	Fracture Pressure (lb/gal)
1	2390	1590	11,4
2	2100	1580	9,3
3	2900	1580	10,4
4	4400	1580	11,0
5	2600	1530	9,8
6	1740	1380	104
7	2470	1380	10,8
8	2650	1770	10,8
9	2670	1940	10,8
10	4630	1940	14,1
11	1940	1580	10,0
12	2890	1580	11,6

Narrow Operational Window



Excessive Frictional Pressure Losses Inside the Choke Line

- **The frictional pressure losses inside the choke line can be excessive during a kick circulation**
- **Small inside diameter of the choke line and its long length**
- **The problem is aggravated by the low seawater temperature**

Hydrate Formation

- **High pressure and low temperature at the wellhead are favorable for hydrate formation**
- **Hydrate can plug the kill and choke lines, the annulus space and the BOP cavities.**
- **Hydrate formation can be prevented using inhibitors such as salt and glycol.**

Gas Inside the Riser After BOP Closure

- **In ultra-deep waters, there are chances of the gas has passed through the BOP and into the riser before well closure**

- **The use of synthetic oil based mud increases these chances**

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Research and Development

- **A strategic in-house corporate research program dedicated to ultra-deepwater exploitation systems has been created**

- **Important research projects portfolio in well safety:**

Drilling Hydraulics and Gas Migration
Gas Solubility in Synthetic Oil Based Mud
Kick Simulator for Field Application
Study of Ultra-Deepwater Blowouts

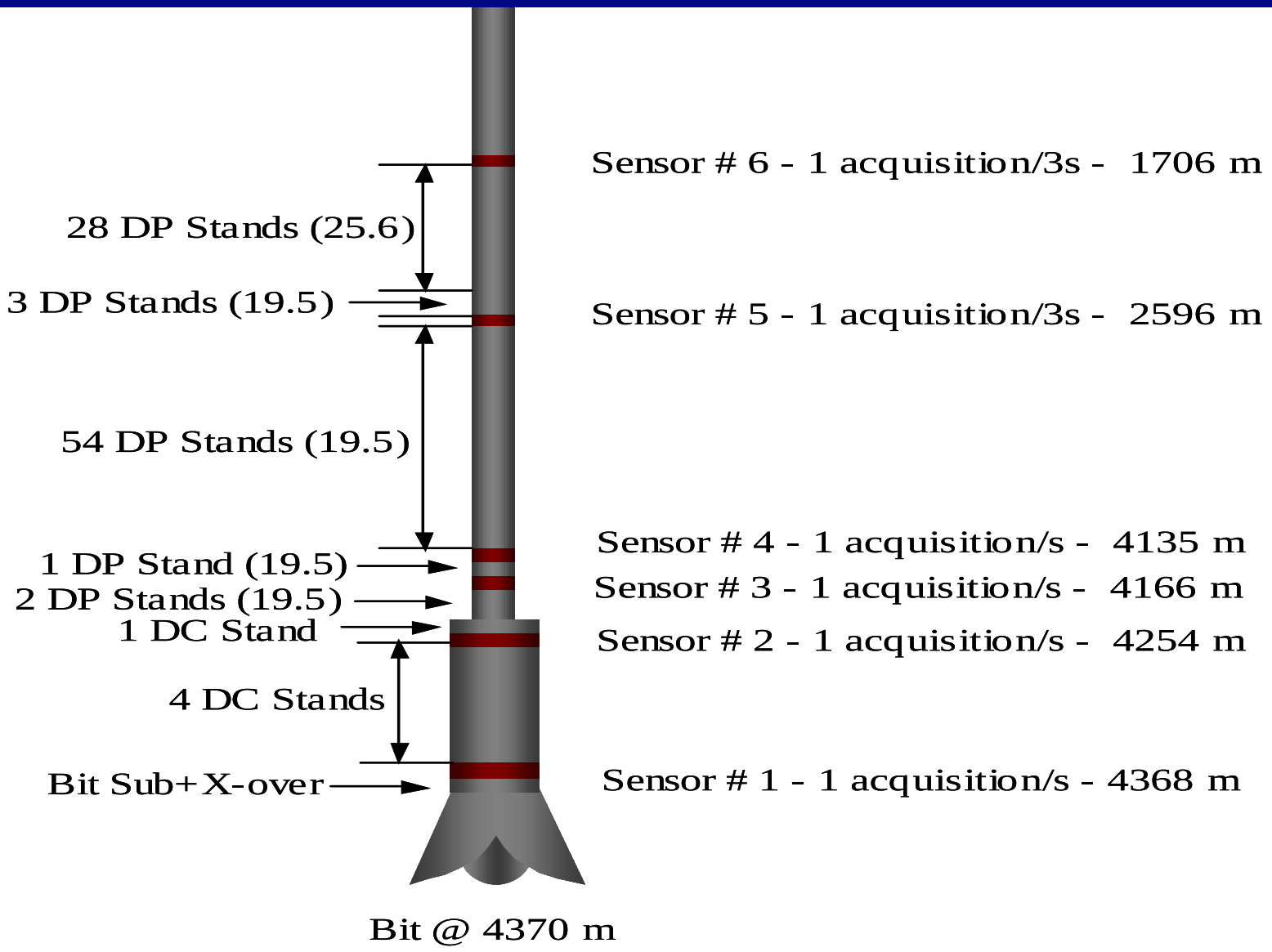
Drilling Hydraulics and Gas Migration

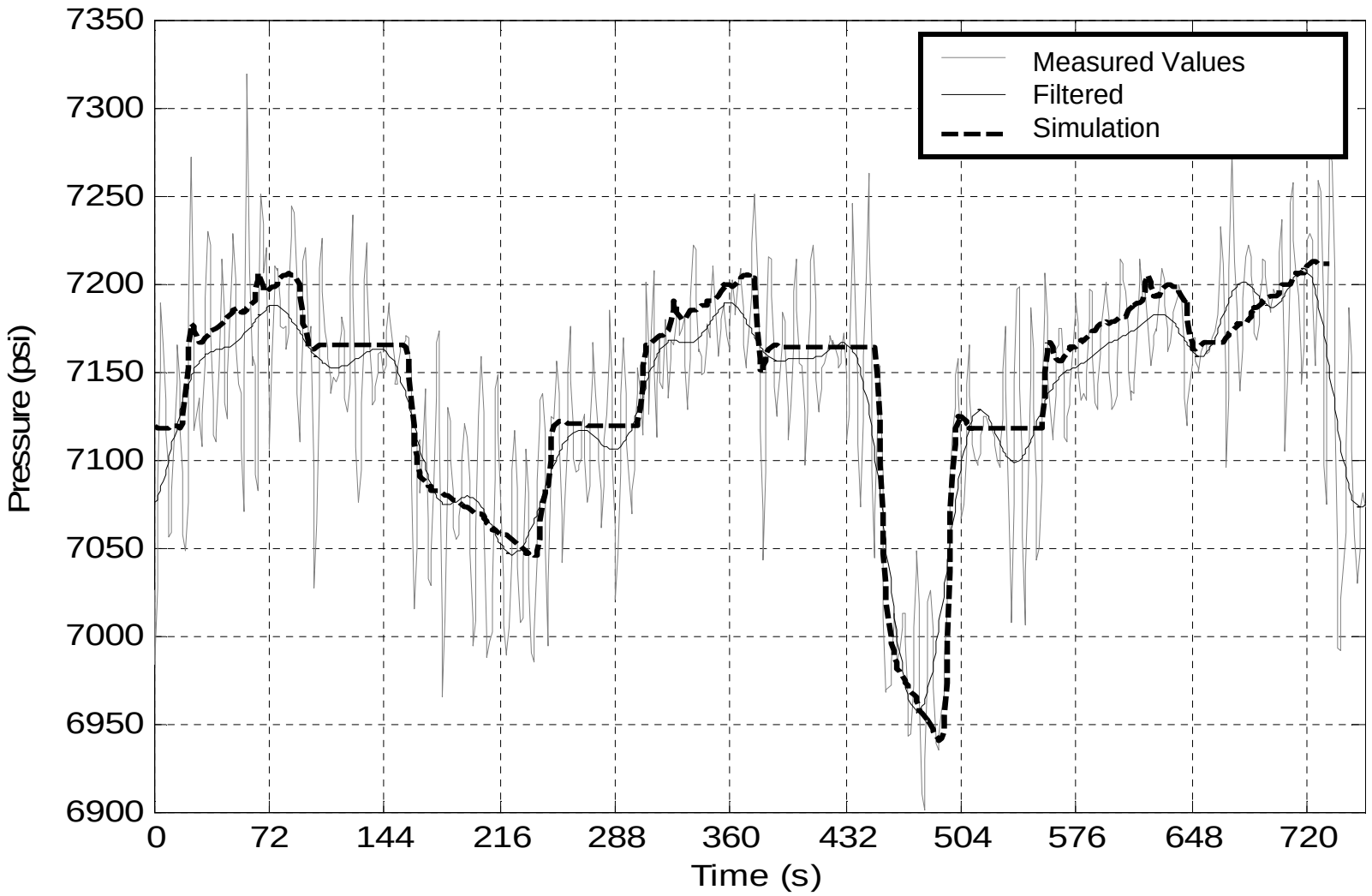
- **Objective: to obtain downhole pressures and temperatures during simulated drilling operations**
- **Issues Addressed: riser hydraulics and temperatures; critical pressure effects (surge and swab); and gas migration**
- **Results: comparison of gathered data with computer models**

Drilling Hydraulics and Gas Migration

- **Research conducted through a JIP coordinated by RF - Rogaland Research that used a drillship Campos Basin (Brazil) in a water depth of 2714 m**
- **The drilling string was equipped with six sensors for recording pressures and temperatures**
- **Gas migration experiments were done through nitrogen injection with the bit just above the BOP**

Drilling Hydraulics and Gas Migration




Measured Values
Filtered
Simulation
Pressure (psi)
7350
7300
7250
7200
7150
7100
7050
7000
6950
6900
0
72
144
216
288
360
432
504
576
648
720
Time (s)

Gas Solubility in Synthetic Oil Based Mud

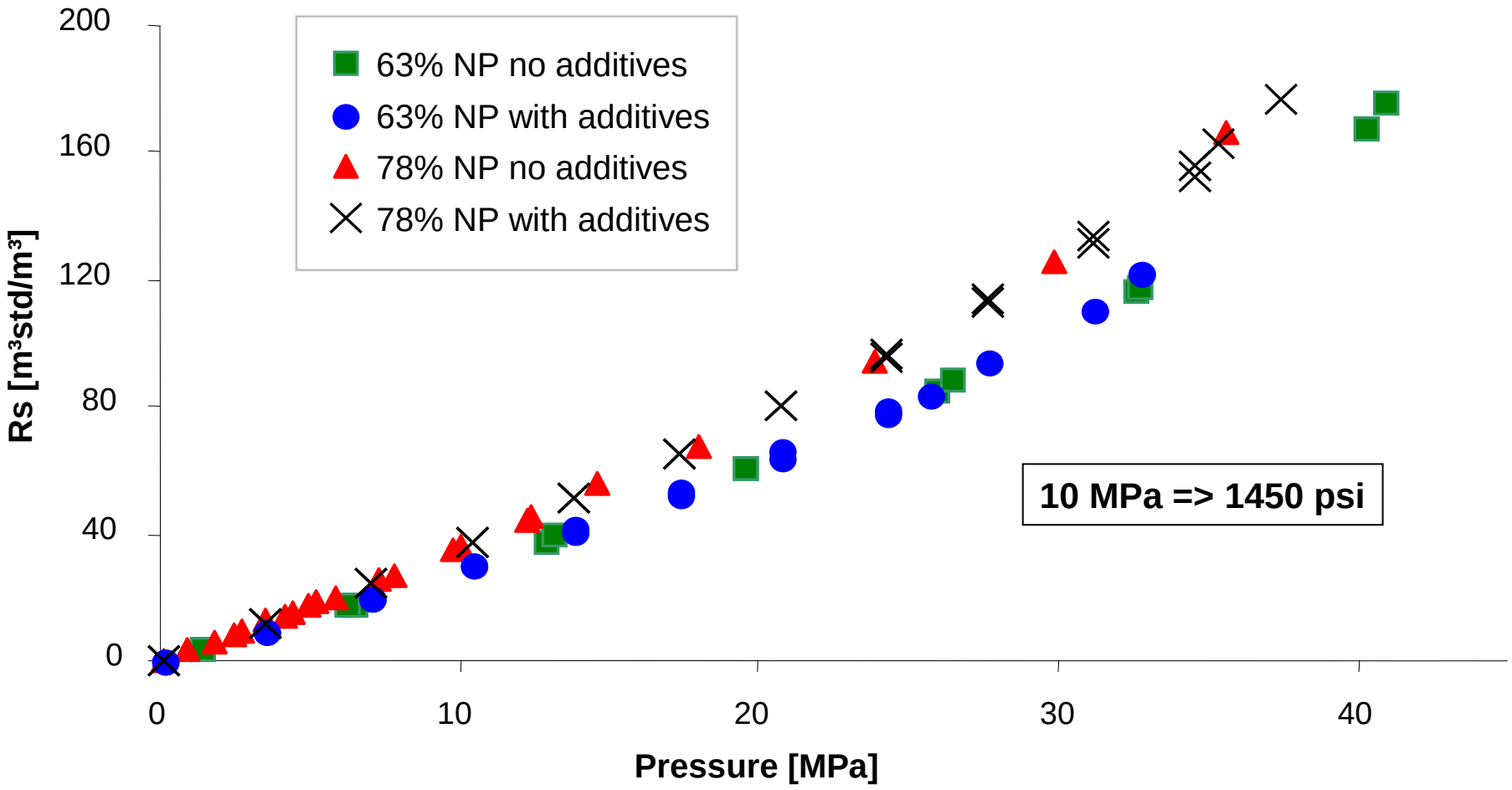
- **Objective: to understand the interaction between a gas kick and a synthetic oil based mud**
- **Issues Addressed: experimental determination and modeling of thermodynamic properties**
- **Results: experimental data of gas solubility (methane), density and formation volume factor for n-paraffin, ester, emulsions and drilling fluids**

Gas Solubility in Synthetic Oil Based Mud

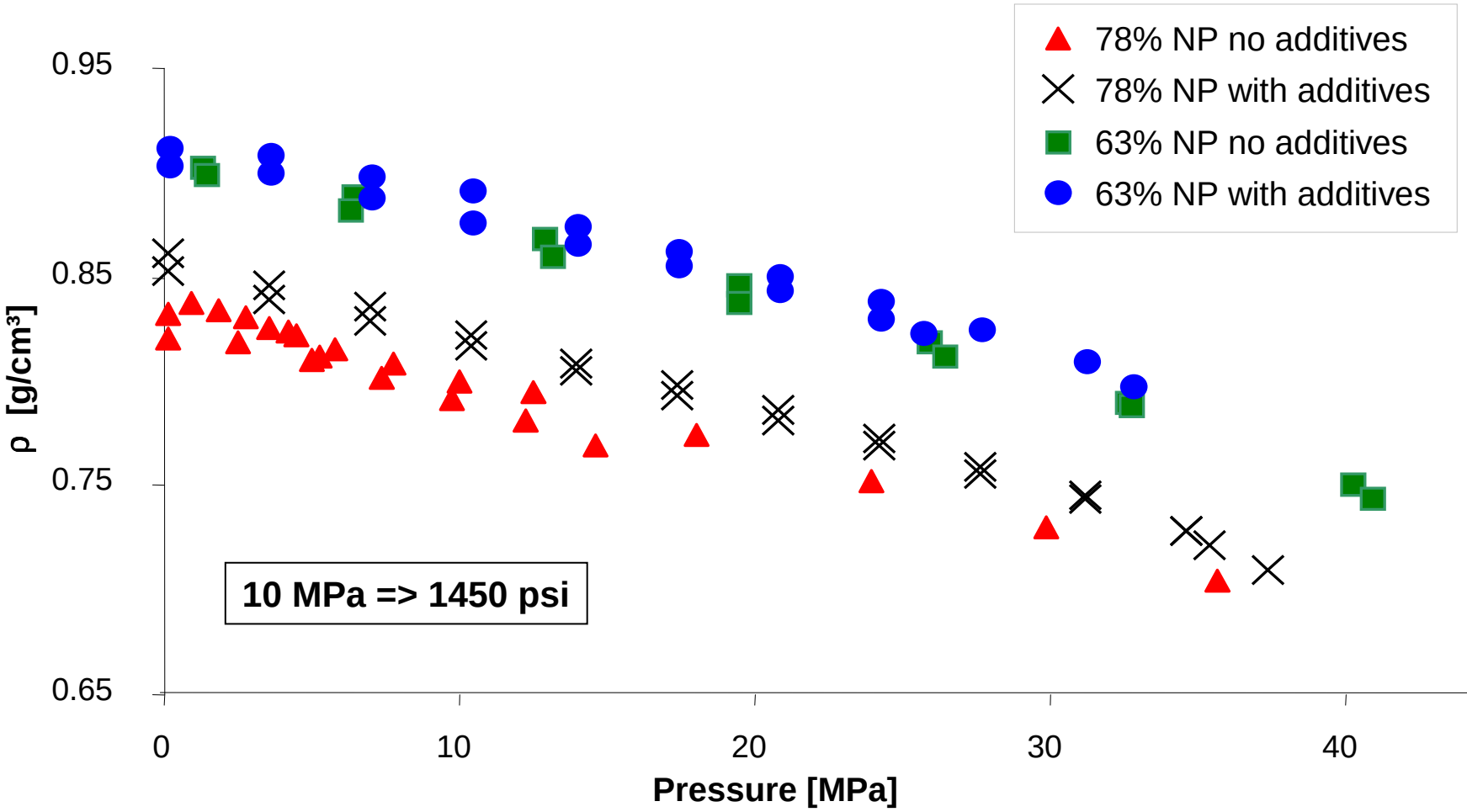
- **Research conducted at UNICAMP (Campinas State University) in a PVT cell with an operating capacity of 177 ºC and 10000 psi**
- **The current experiments aim at expanding the ranges of pressure and temperature using a new PVT cell with an operating capacity of 200 ºC and 15000 psi**

The New PVT Cell

Gas Solubility in the Unweighted Drilling Fluid at 70ºC



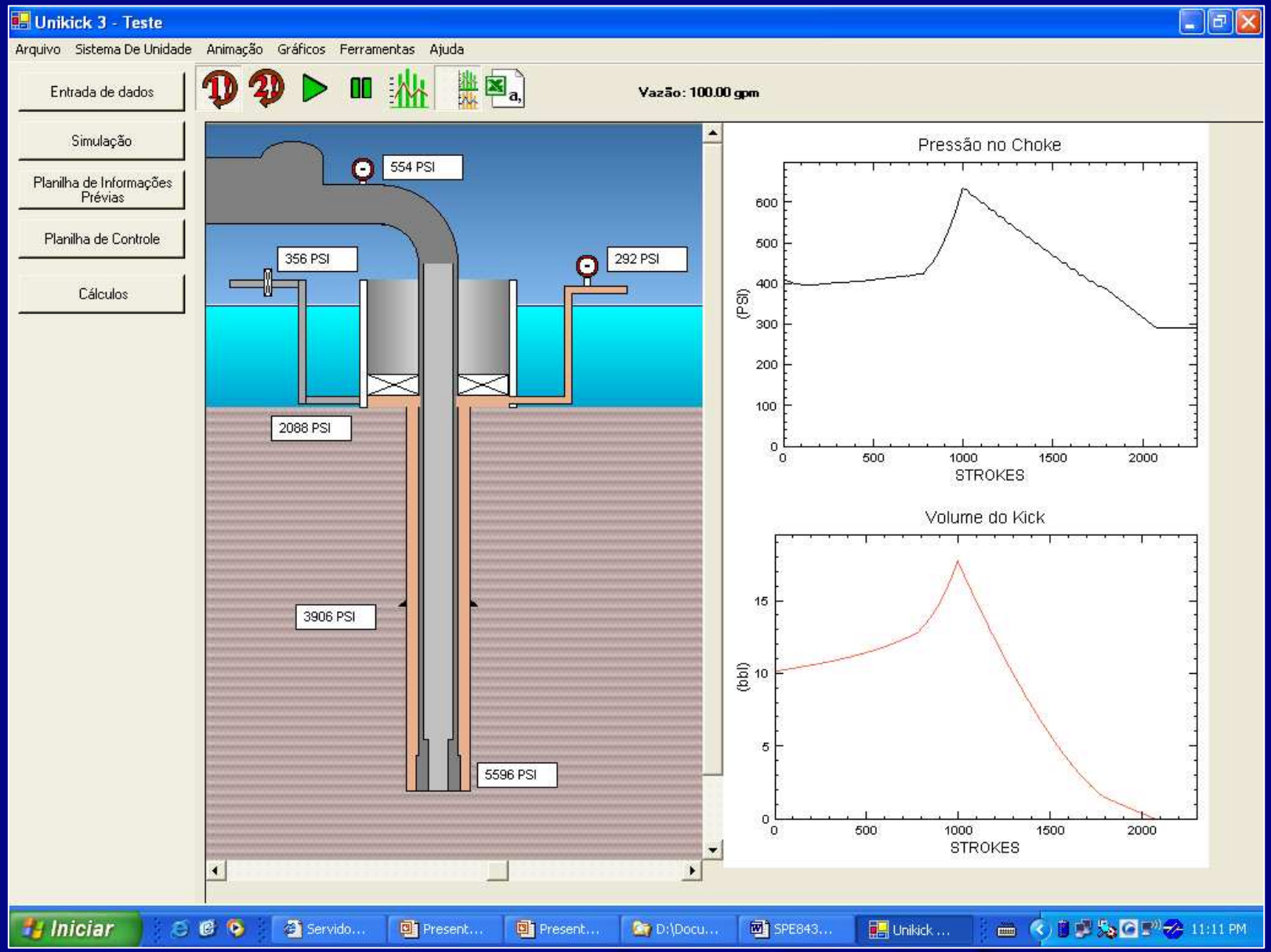
Density of the Unweighted Drilling Fluid at 70ºC



Development of a Kick Simulator

- **Objective: to develop a software to assist the drilling engineer in well control issues on an ultra-deepwater drilling rig**
- **Issues Addressed: estimation of pressure behavior inside an ultra-deepwater well during a gas kick circulation and calculation of kill sheets**
- **Result: a software to be used by the drilling personnel at rig site**

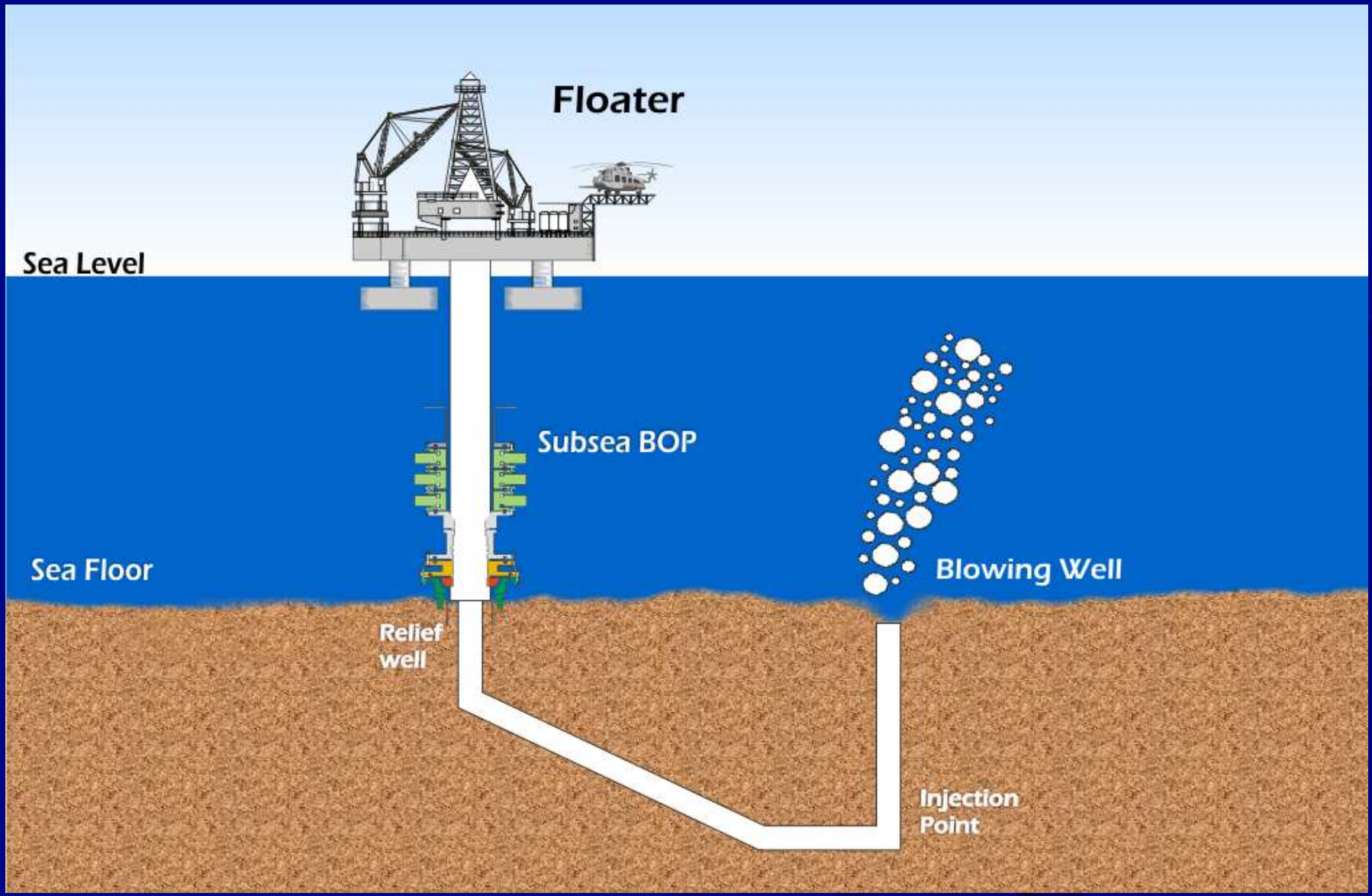
Kick Simulator Output



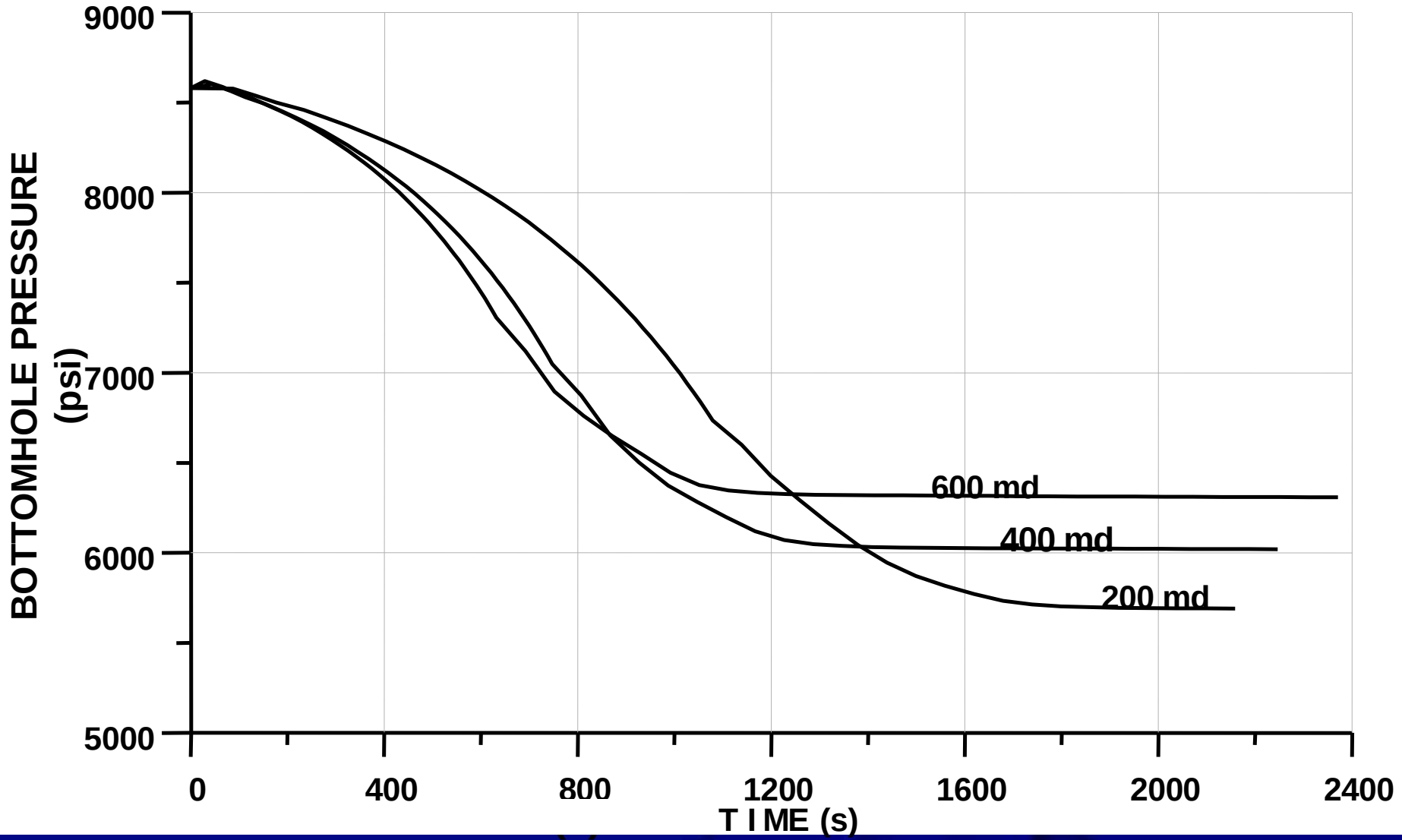
Study of Ultra-deepwater Blowouts

- **Objective: to study ultra-deepwater blowouts and their control through the dynamic kill method using relief wells**
- **Issues Addressed: pressure behavior and gas flow rate during blowouts and the application of the dynamic kill method**
- **Products: two simulators, one for blowout events and the other for dynamic kill method**

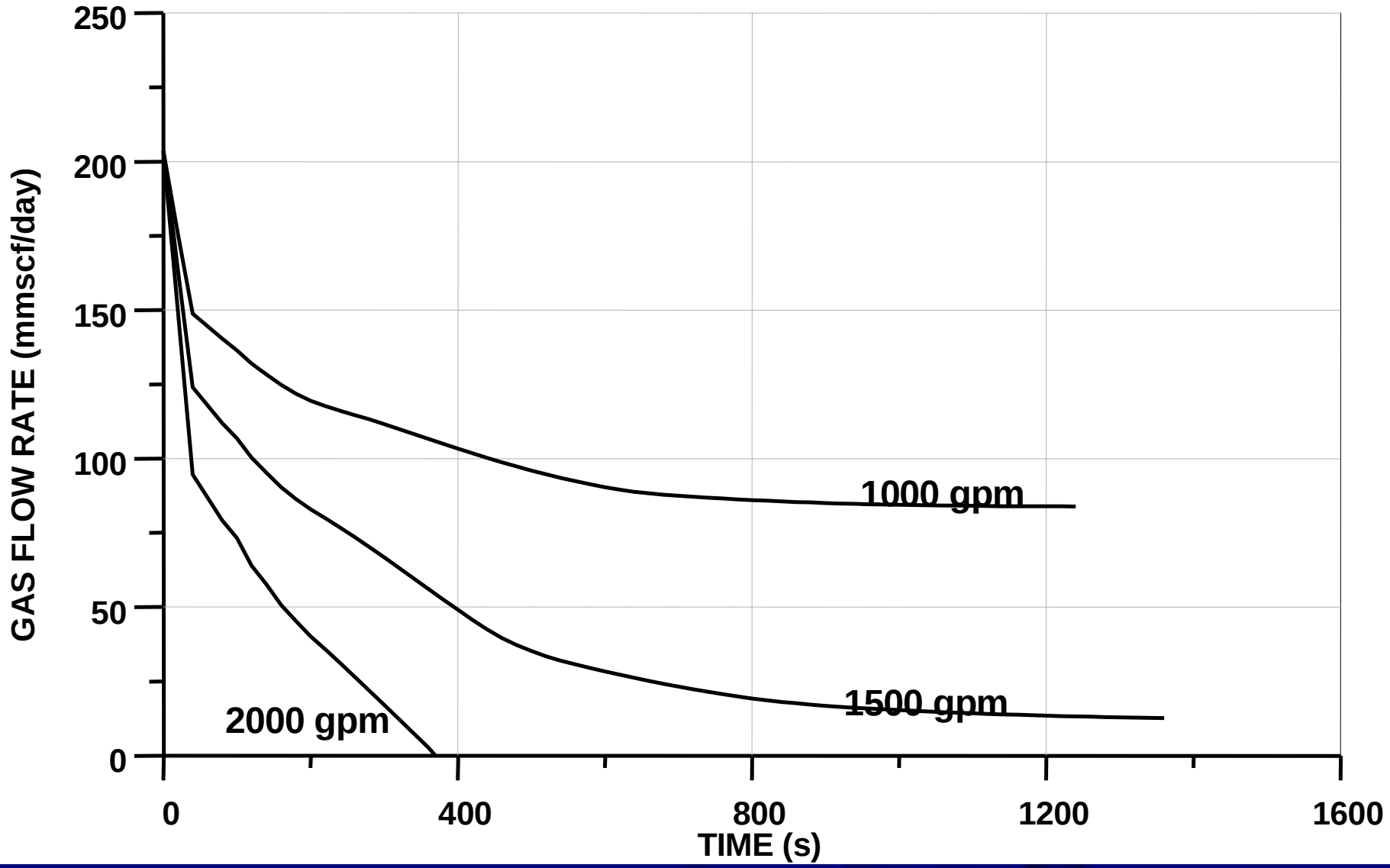
Subsea Blowout



Subsea Blowout



Dynamic Kill from a Relief Well



Conclusions

- **Effective preventive actions make onshore and offshore drilling and production operations safer**
- **Training, well control equipment tests and elaboration of safety standards are some of these actions that were responsible for the decrease of the number of blowouts in Brazil**
- **Research projects enhanced the understanding of the well safety processes**

Questions?

Distinguished Lecturer Program

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