



Distinguished Lecturer Program

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Distinguished
Lecturer Program

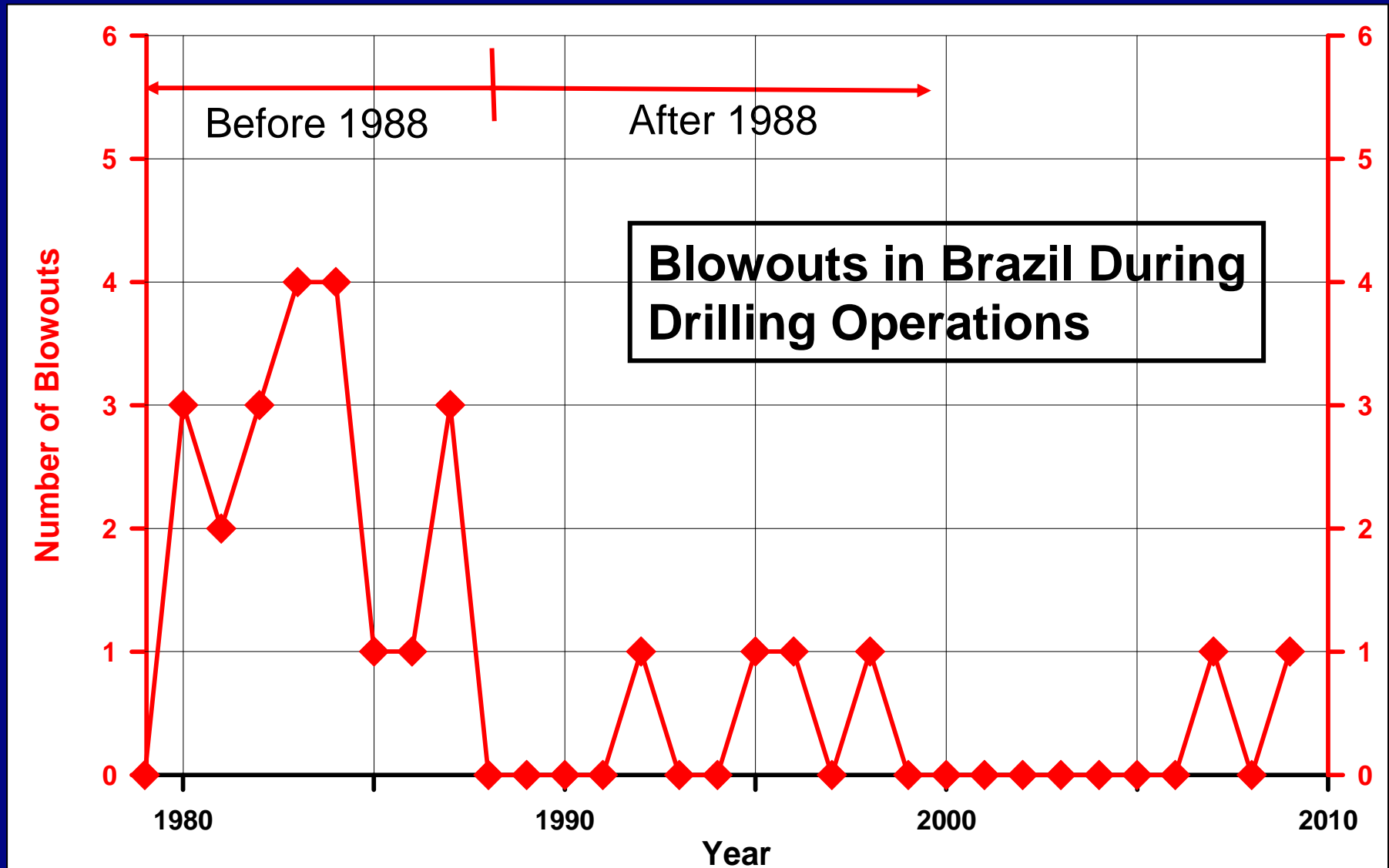
Ways to Successfully Reduce Well Blowout Events

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Petróleo Brasileiro S.A. - Petrobras

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl



Motivation for the Lecture





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



- **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**



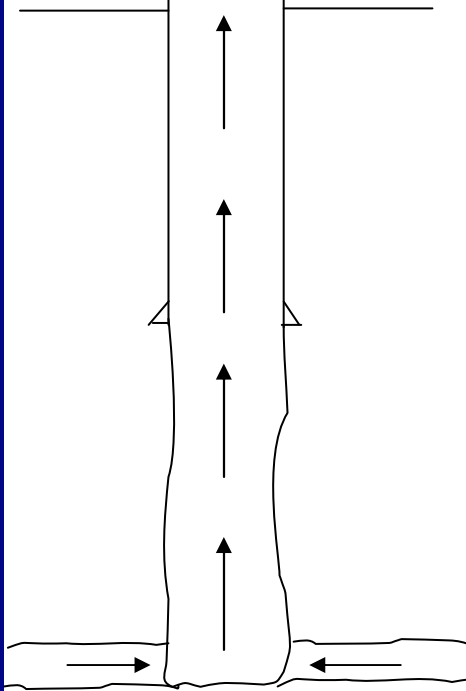
Kicks and Blowouts Definitions

- **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.**

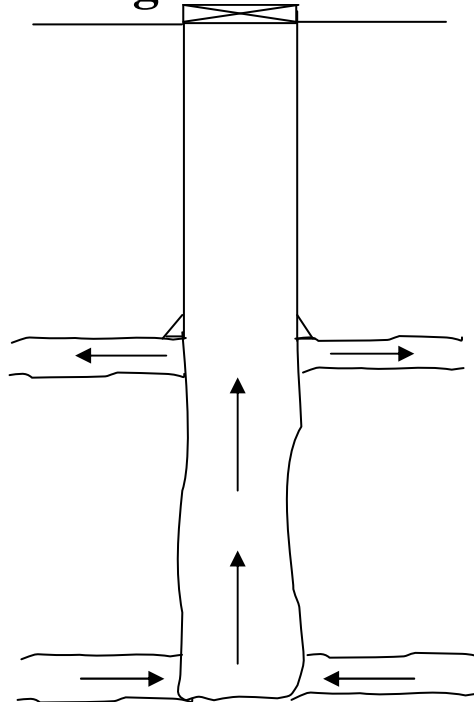


Blowouts Classification

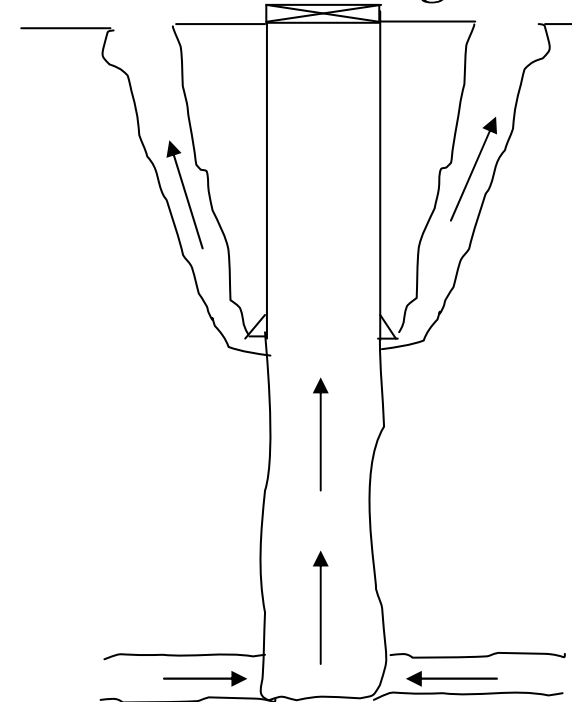
Surface Blowout



Underground Blowout

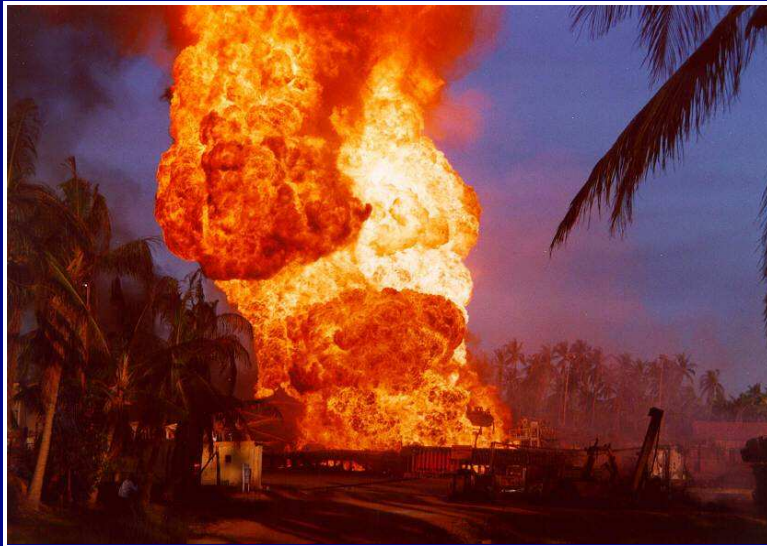


Cratering





Examples of Blowouts





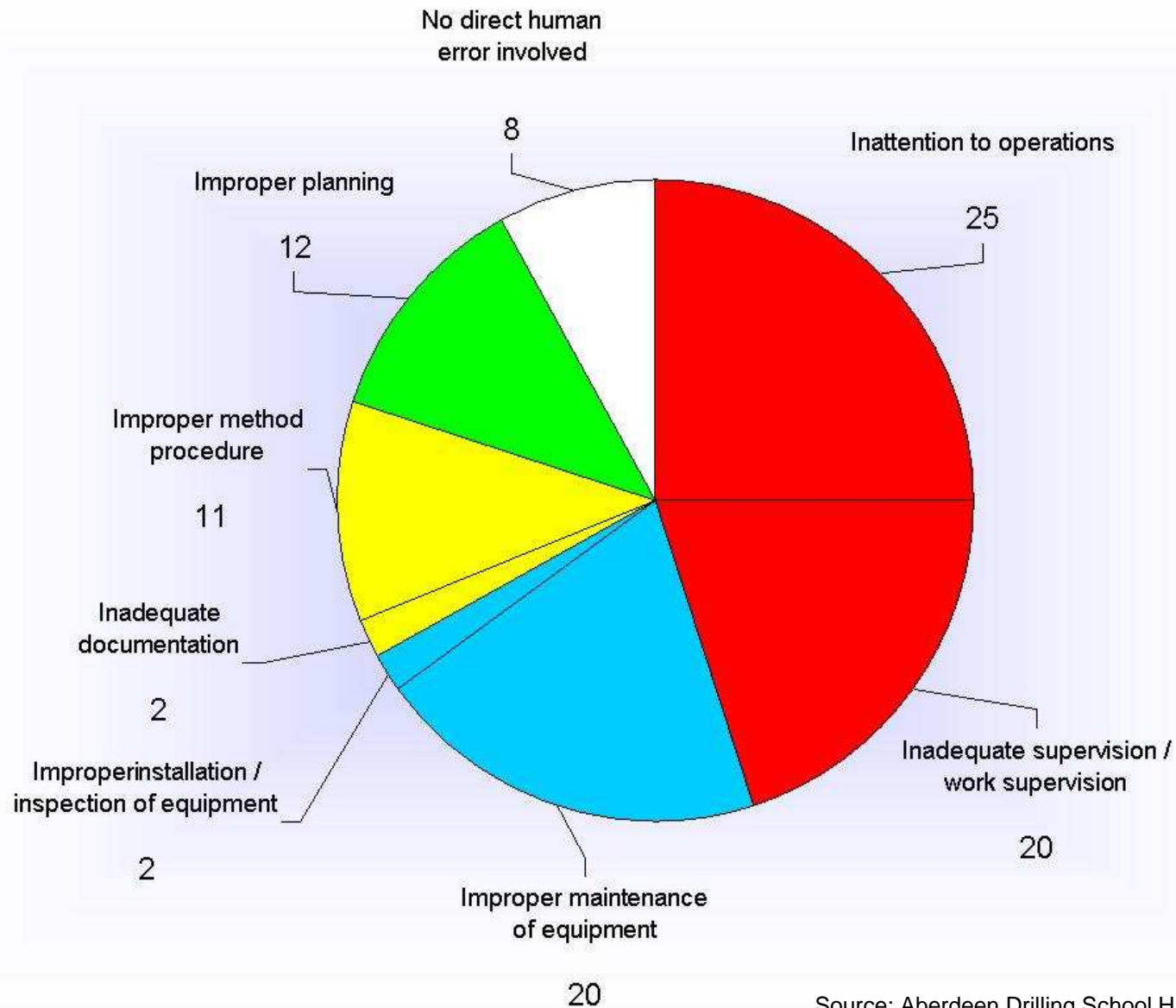
Consequences of a Blowout



- **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**

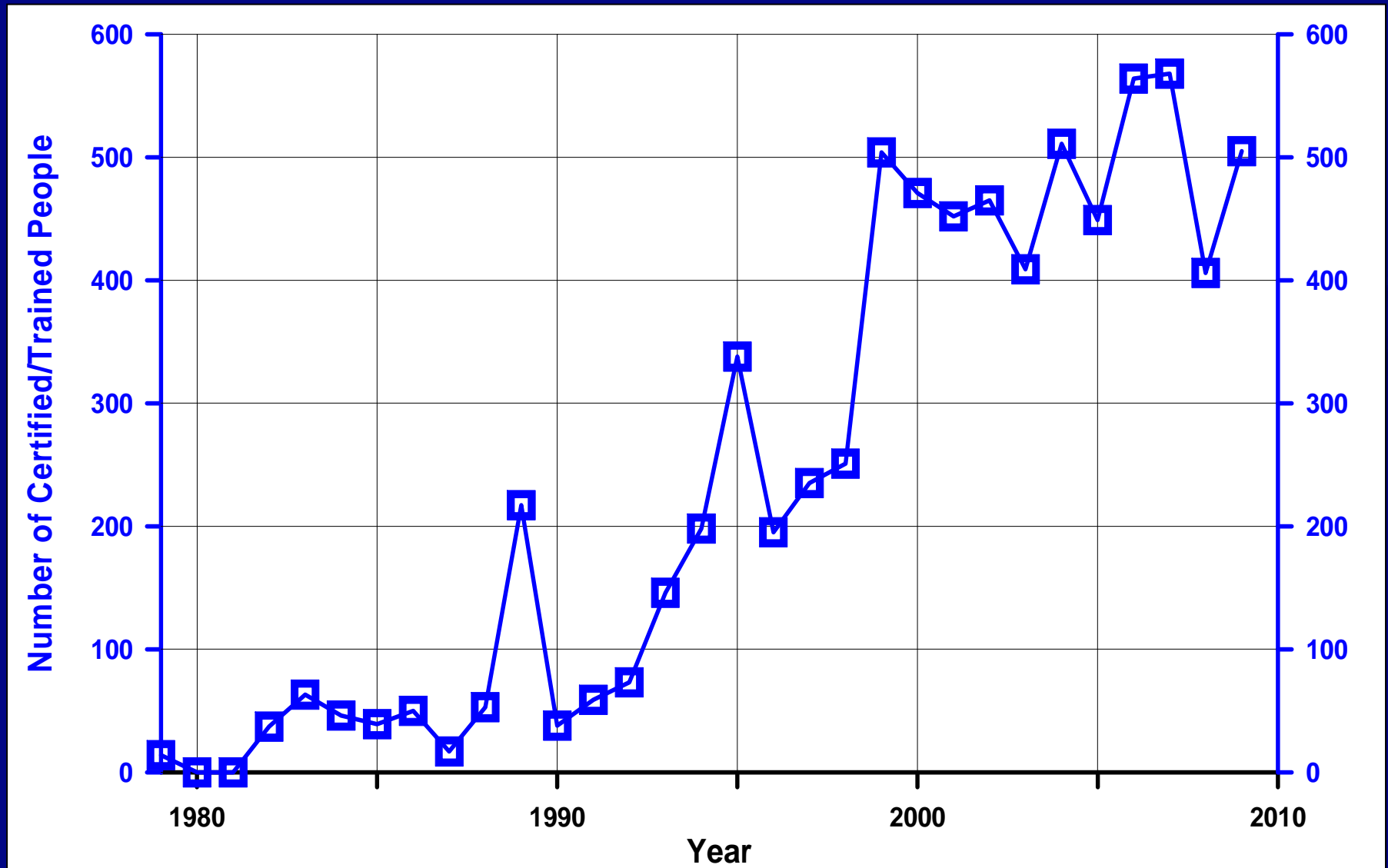


WellCAP Certificates Issued Until 31 December, 2009

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



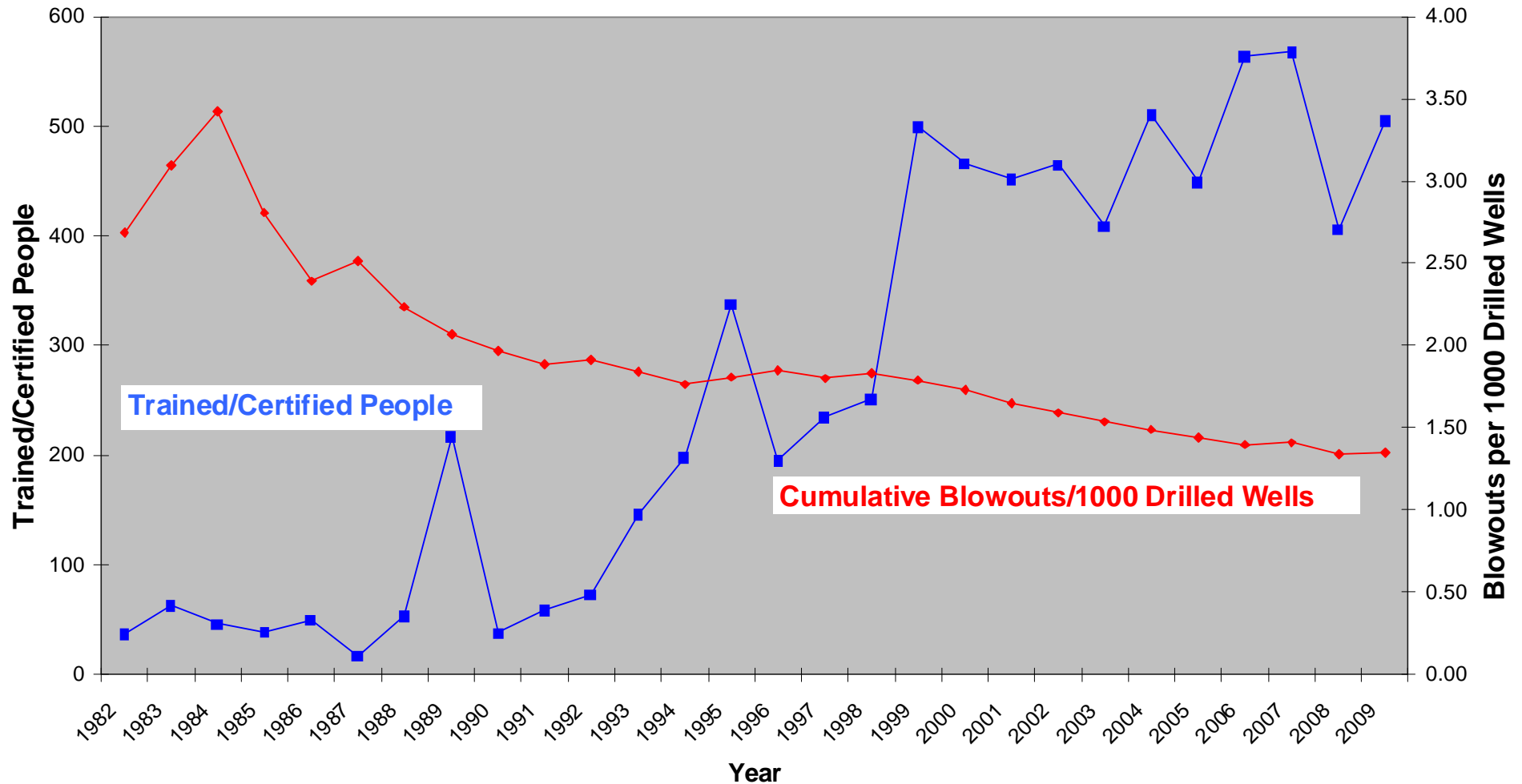
Trained/Certified People





Cumulative Blowouts in Brazil per 1000 Drilled Wells

Blowouts in Brazil per 1000 Drilled Wells X Trained/Certified People





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Well Control in Drilling and Production Operations

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**



Well Control in Drilling and Production Operations

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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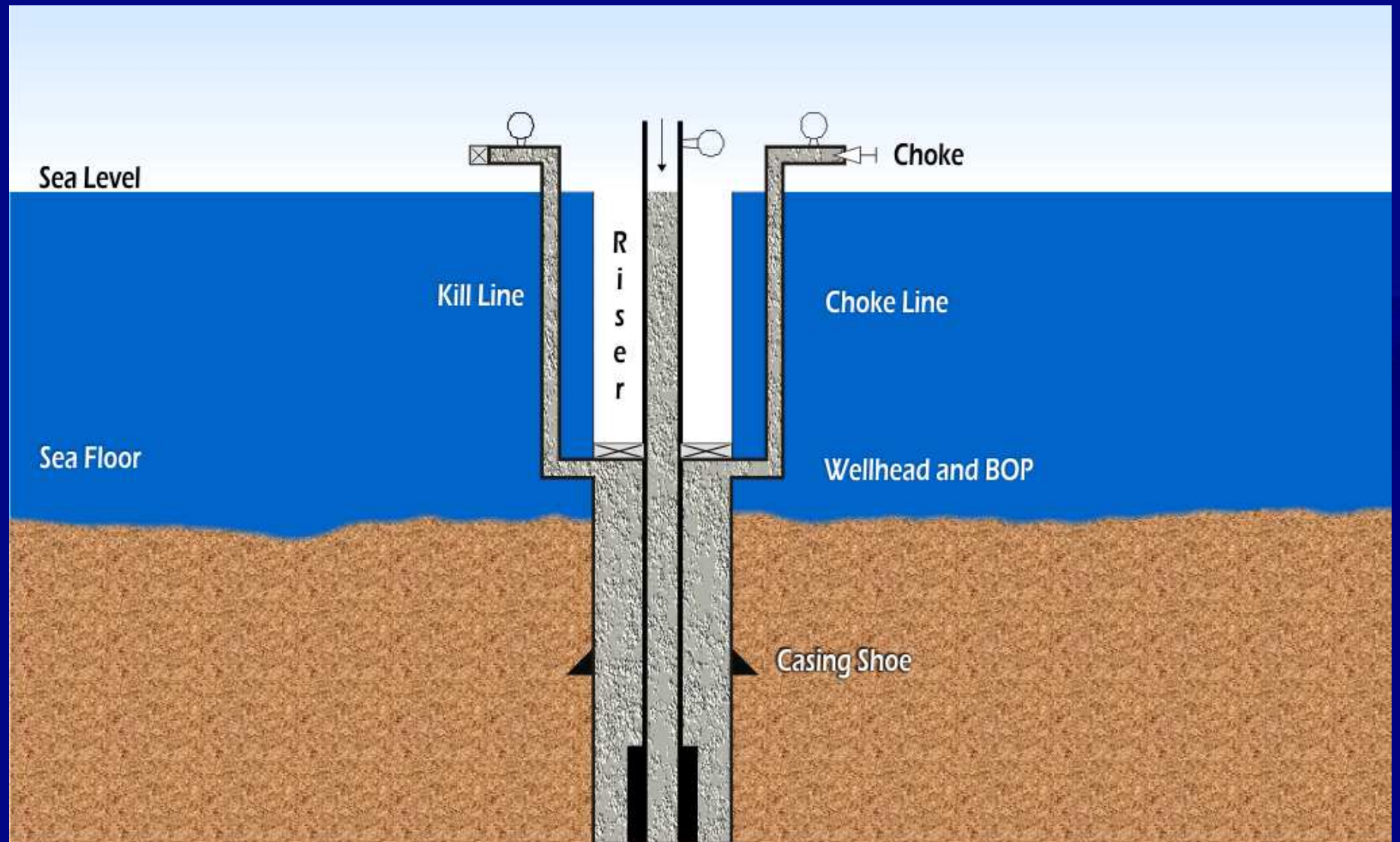


Peculiarities of deepwater and ultra-deepwater well control

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



Subsea Configuration





- **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**

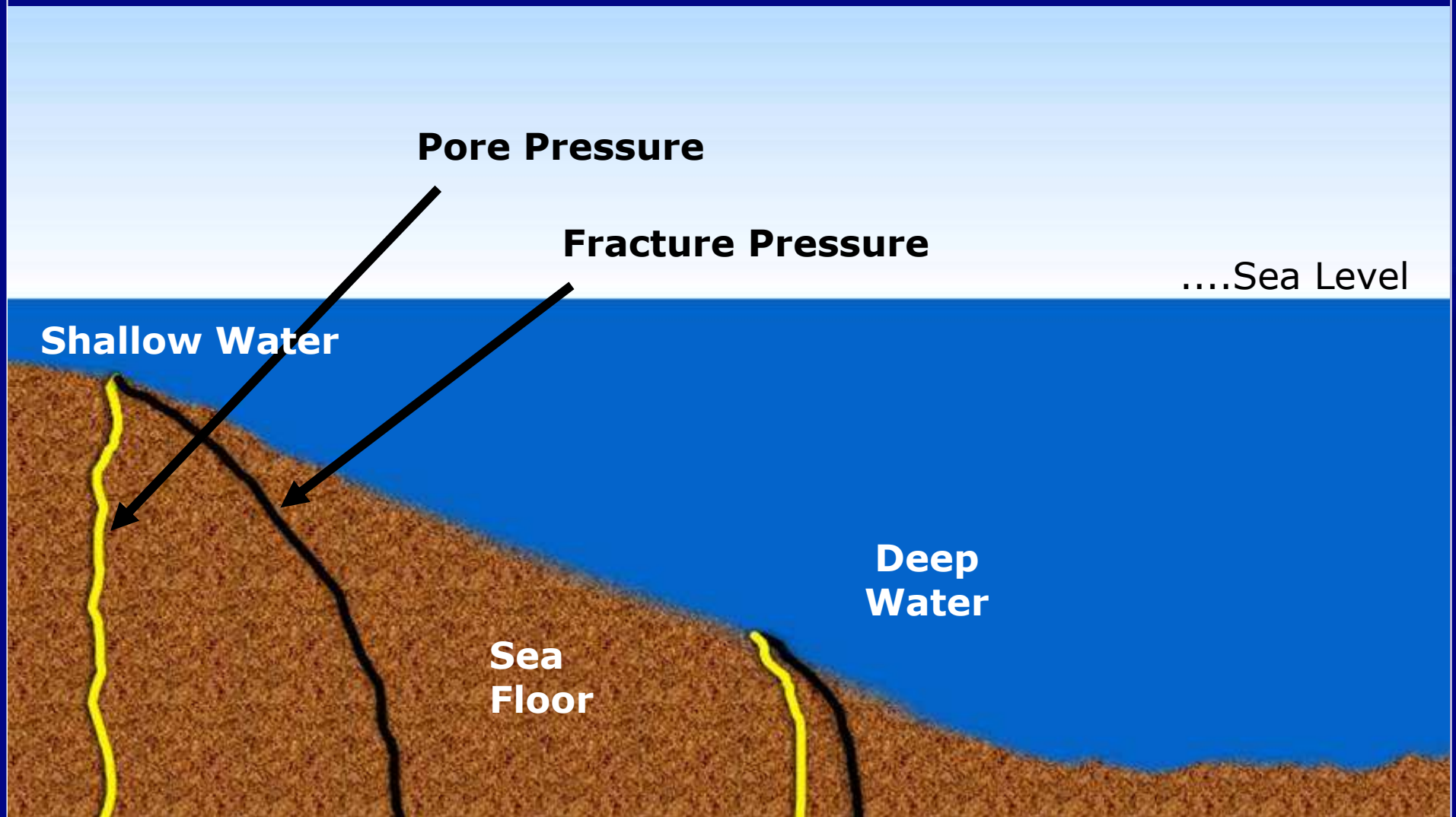


Low Fracture Pressure

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	10,4
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 in Well Control in Ultra-Deep Waters**
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- **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

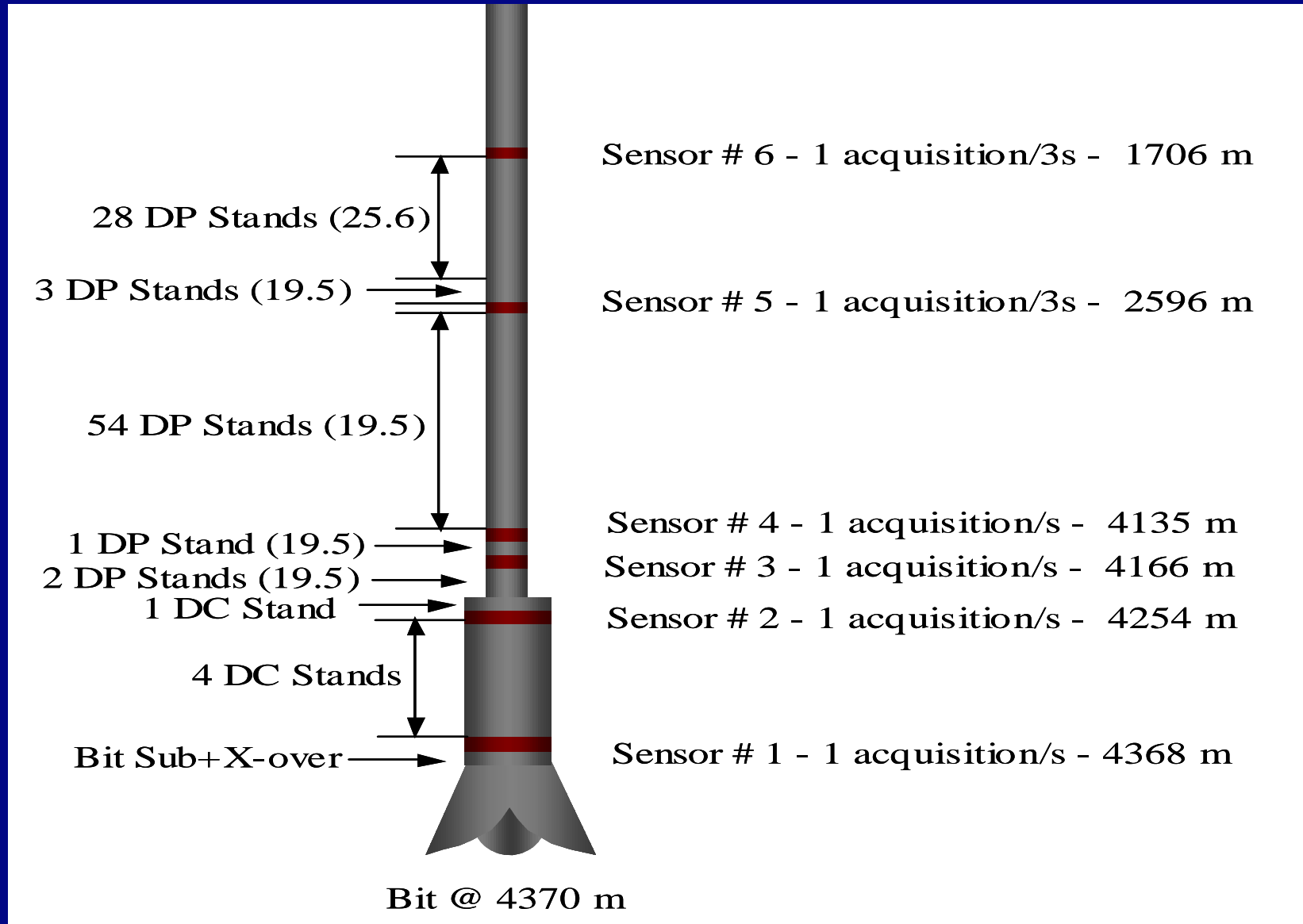
- **Objective:** to obtain downhole pressures and temperatures during simulated drilling operations
- **Issues Addressed:** riser hydraulics and temperatures; critical pressure effects (surge and swab); and gas migration
- **Results:** comparison of gathered data with computer models



- **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**

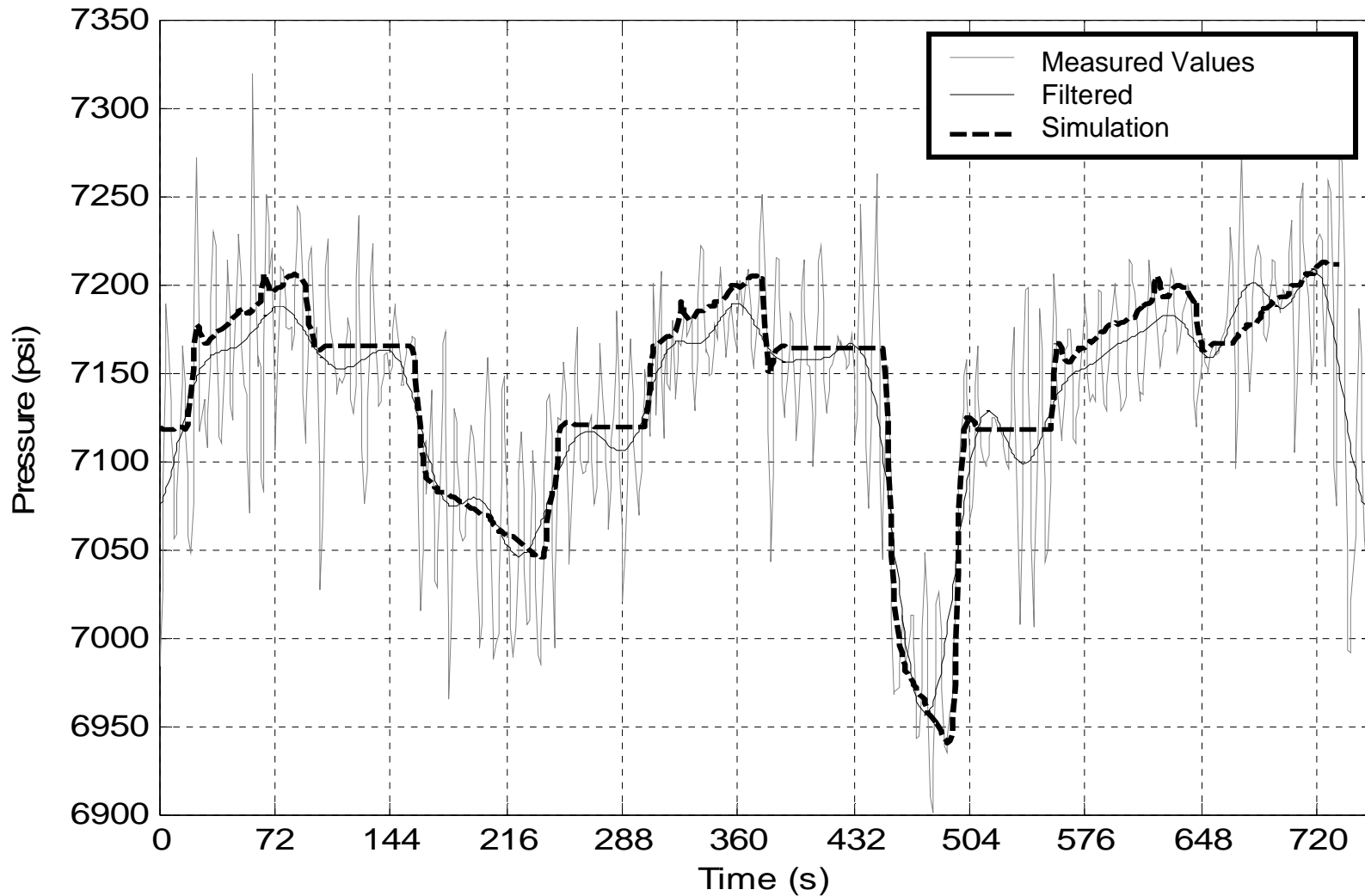


Drilling Hydraulics and Gas Migration





Drilling Hydraulics and Gas Migration





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 °C 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 °C and 15000 psi**

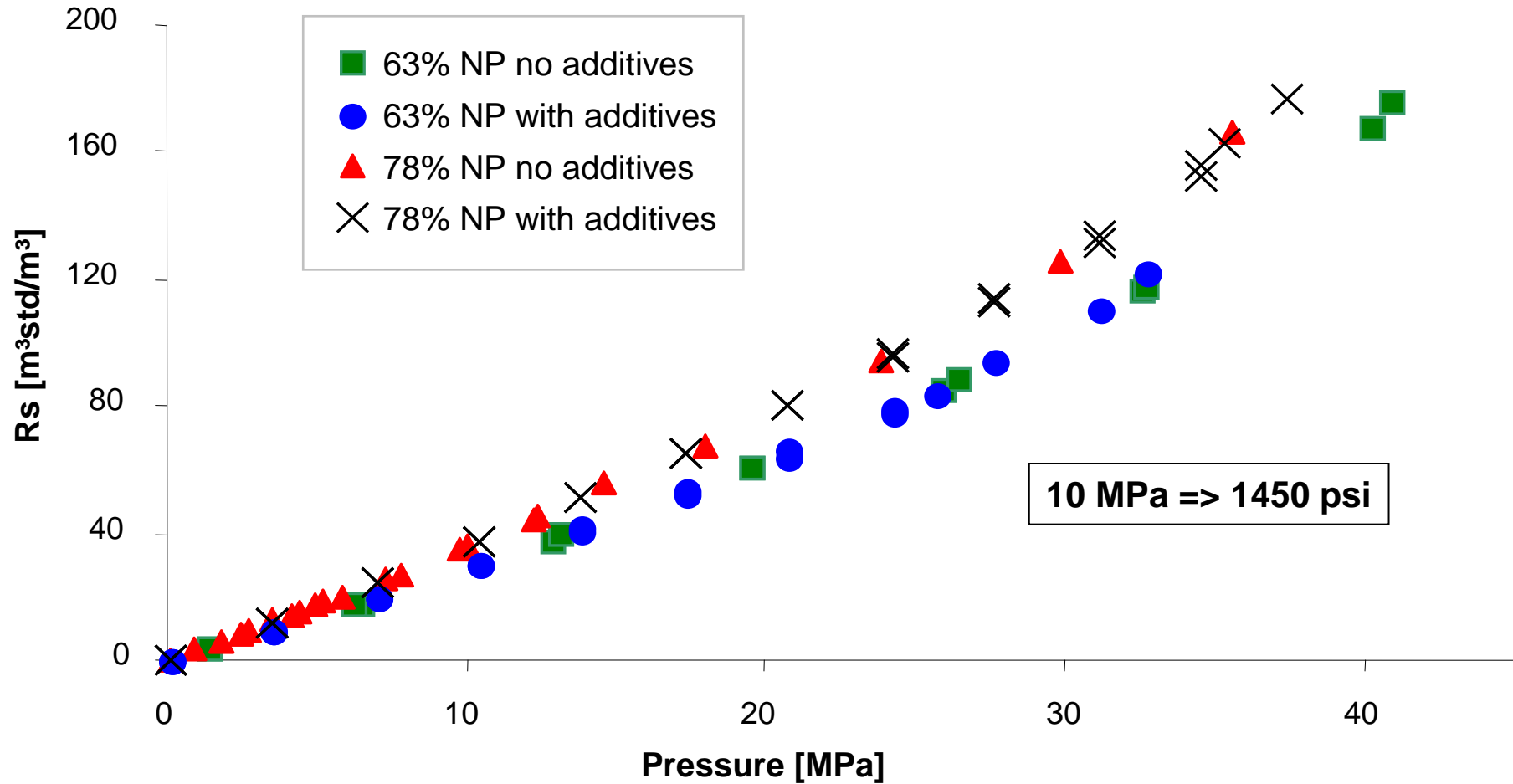


The New PVT Cell



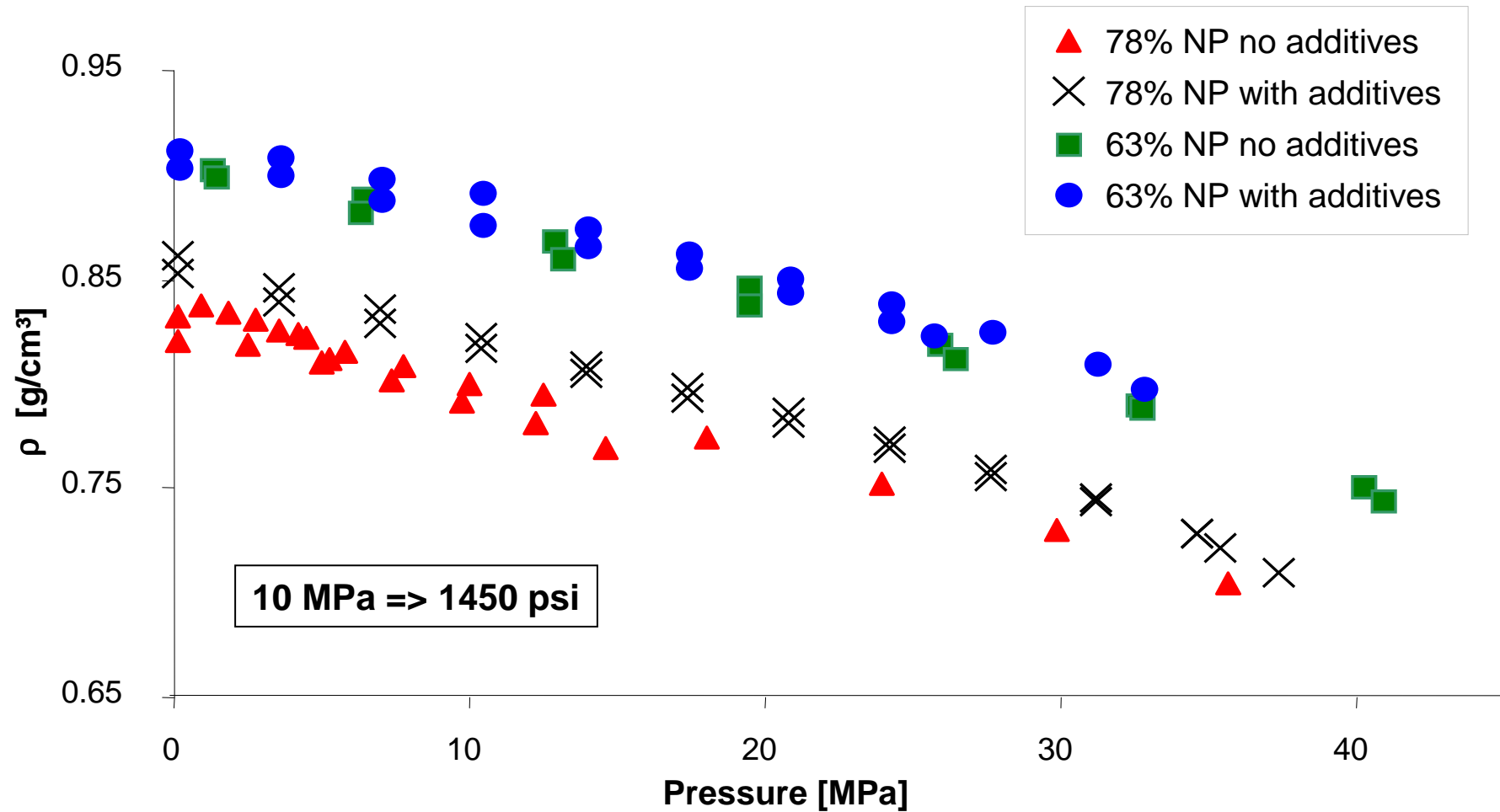


Gas Solubility in the Unweighted Drilling Fluid at 70°C





Density of the Unweighted Drilling Fluid at 70°C



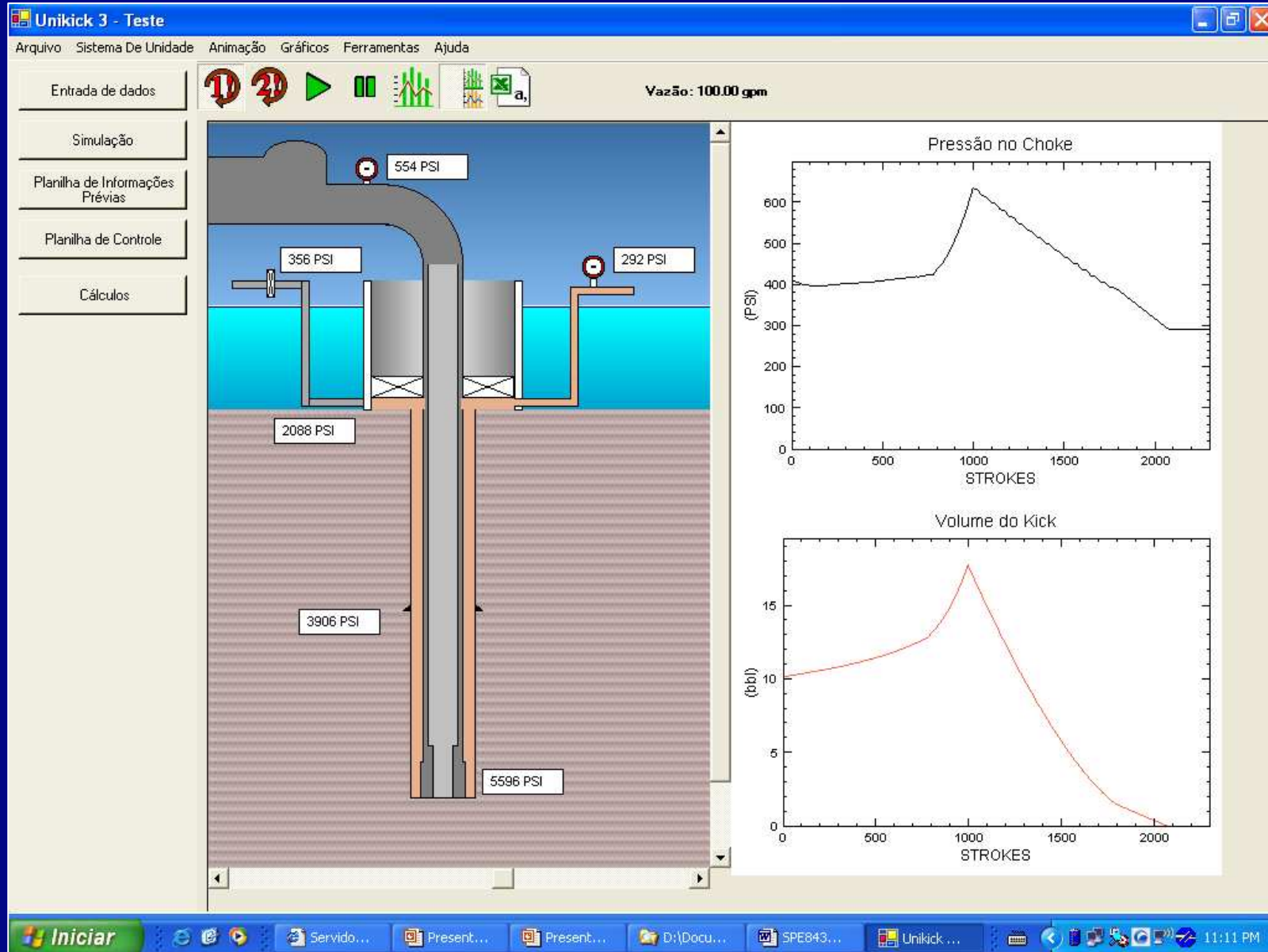


Development of a Kick Simulator

- **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



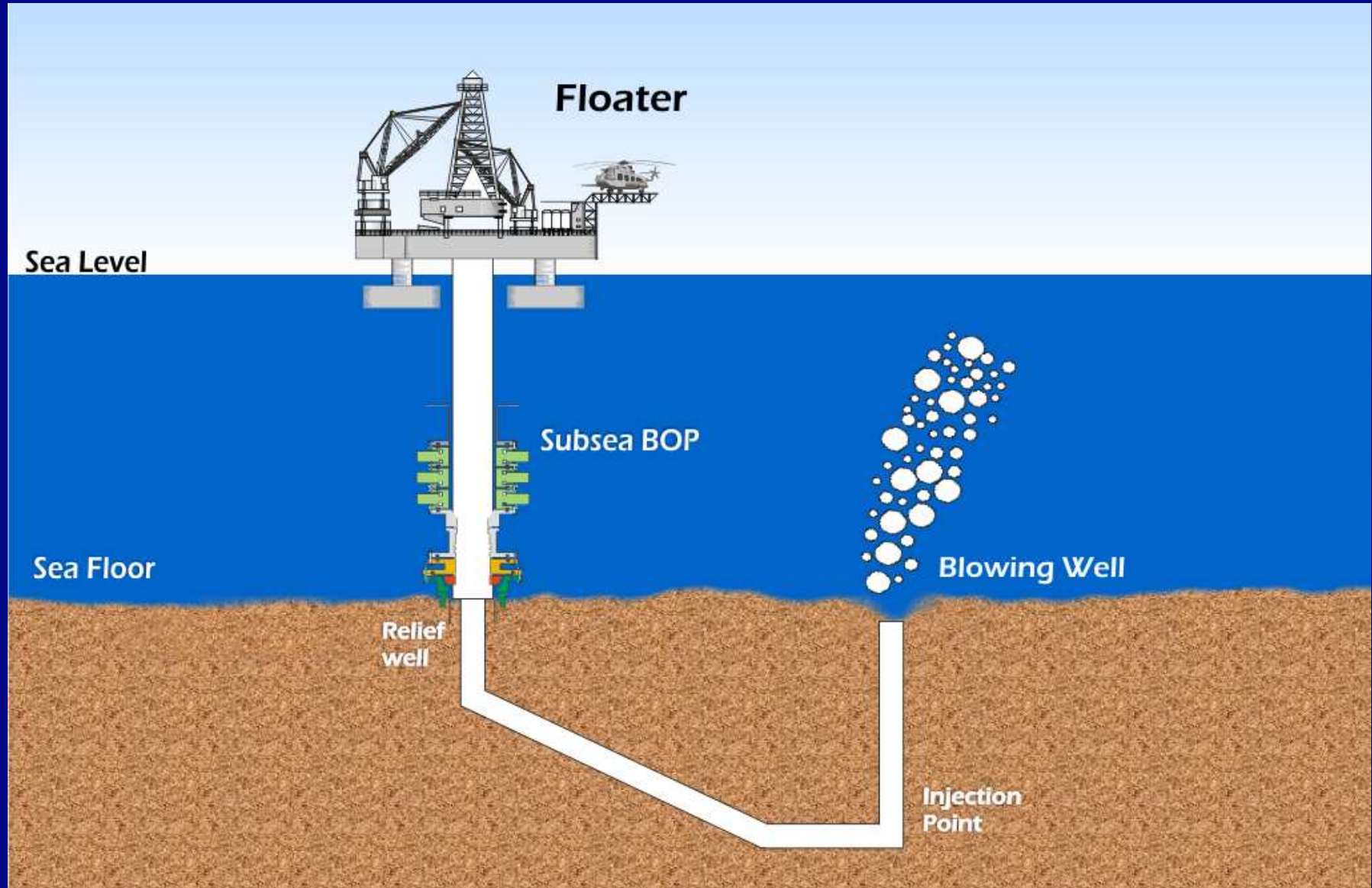


Study of Ultra-deepwater Blowouts

- **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

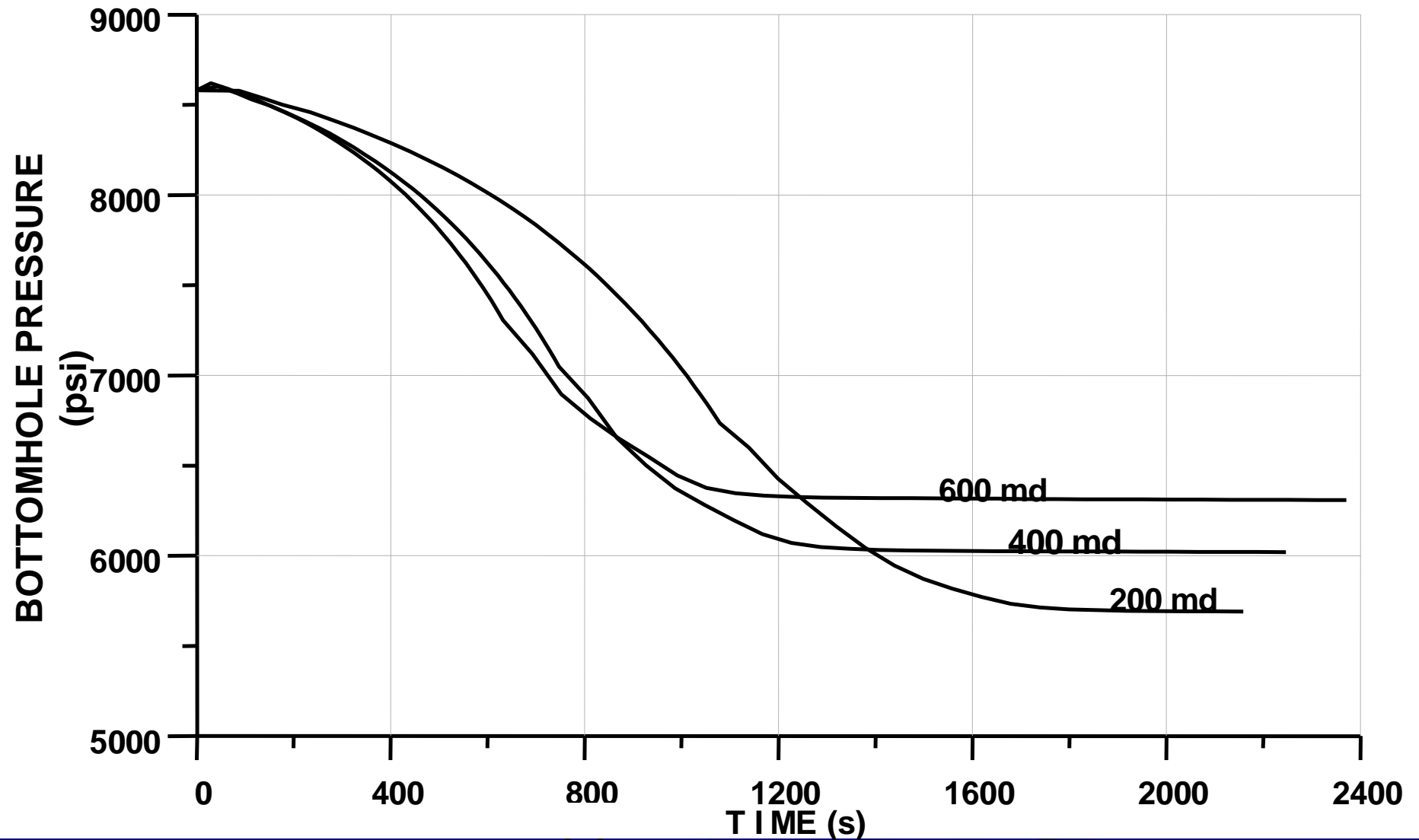


Subsea Blowout



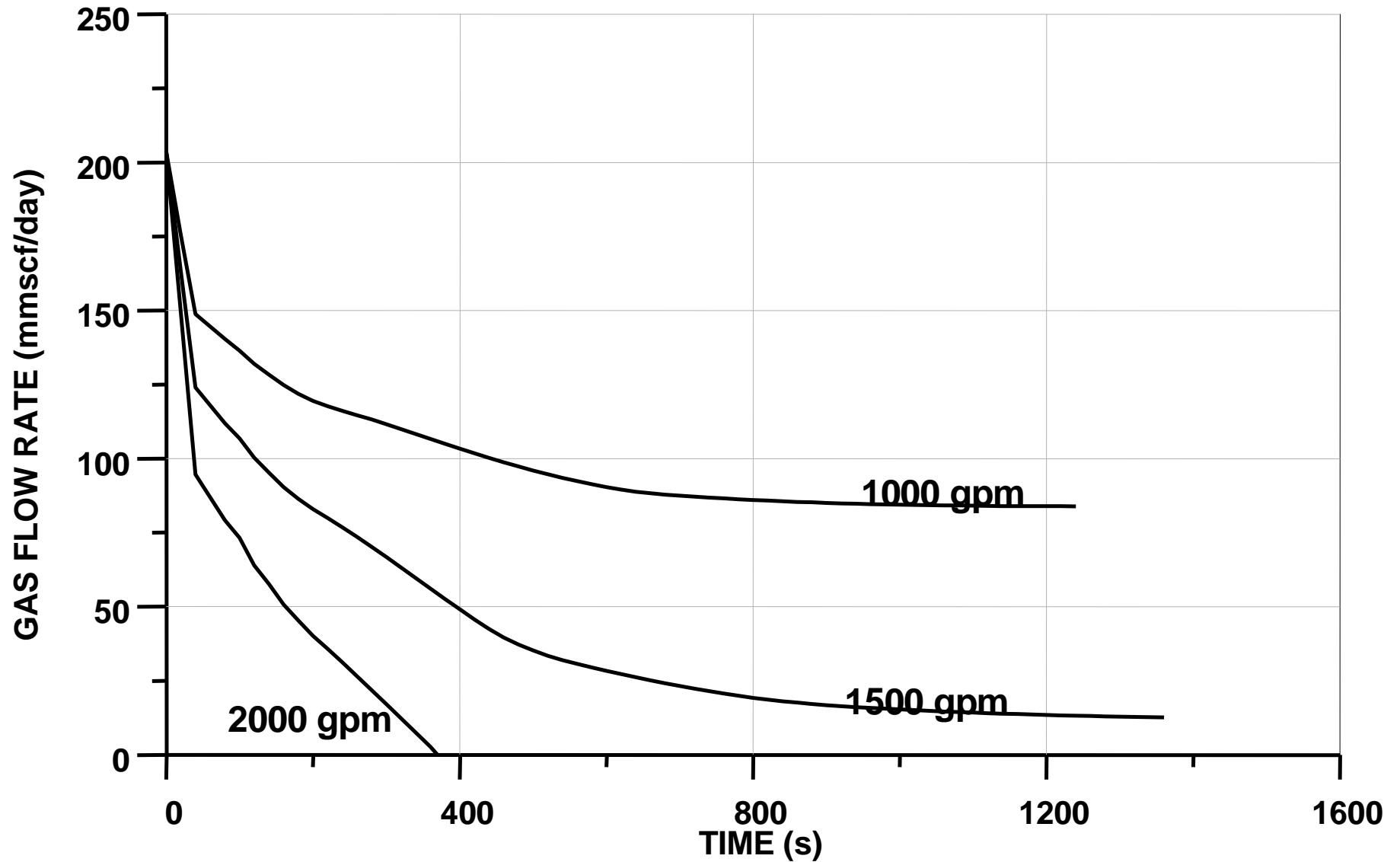


Subsea Blowout





Dynamic Kill from a Relief Well





- **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?



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http://www.spe.org/events/dl/dl_evaluation_contest.php



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