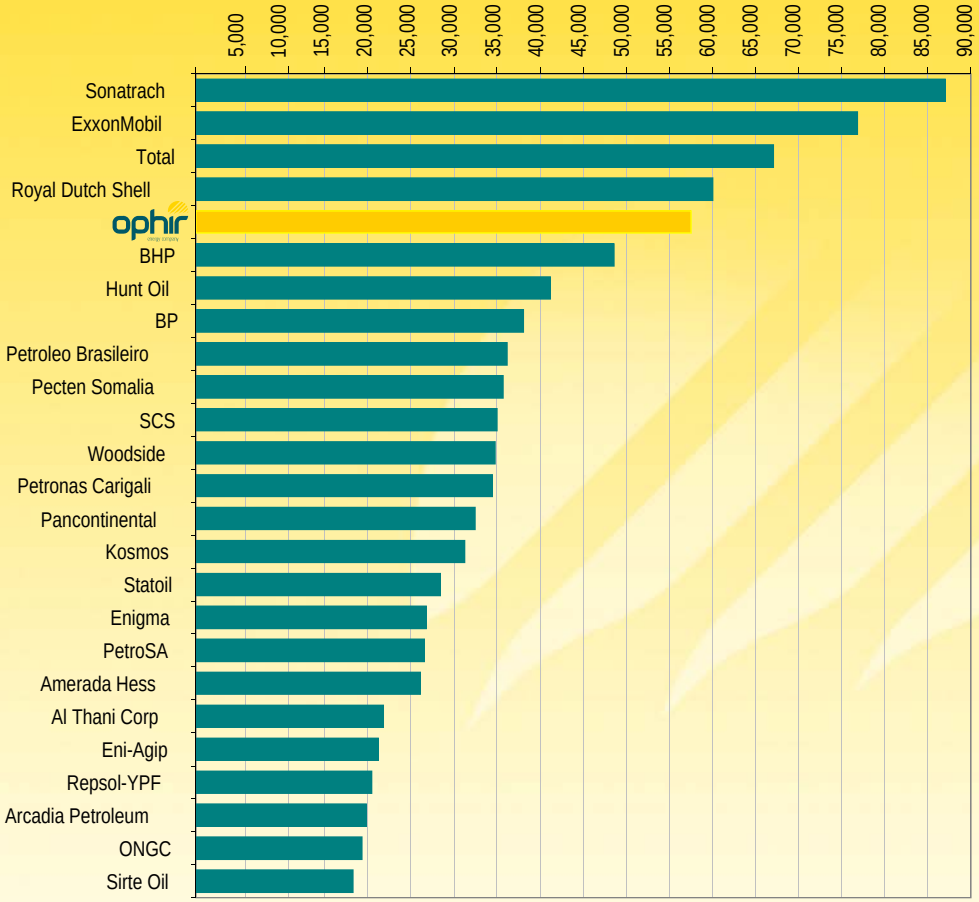
Are SBOPs Safe?

David Bond
Ophir Energy Ltd

Africa - Net Deepwater Acreage (square kilometres or sqkm)



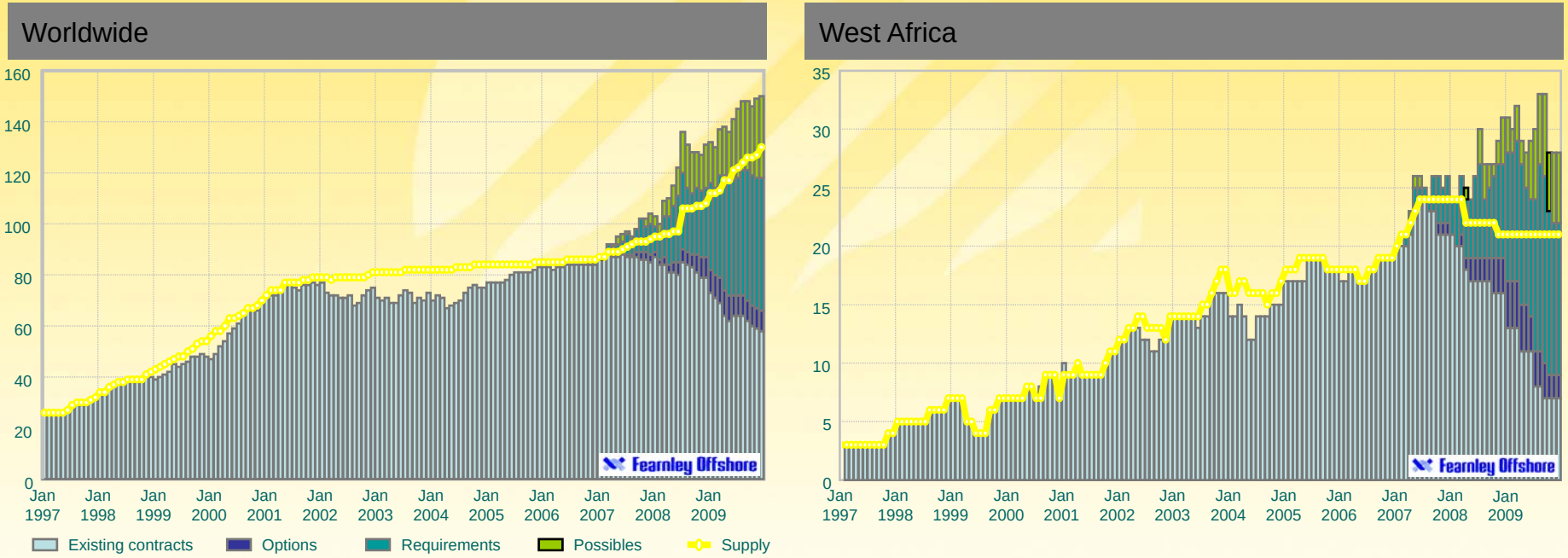
Data extracted from IHS Probe database as of January 2008.
Deepwater defined as any area of water over 250m in depth.
Excludes reconnaissance licences and SADR.

- The upstream landscape in Africa is highly competitive
- Ophir has built an extensive portfolio since 2004
- 5th Largest acreage holder in Deepwater Africa

One of the key constraints facing the oil and gas industry currently is lack of drilling equipment due to increased demand. This is particularly acute for equipment capable of drilling in deepwater.

In 2006, Fearnley Offshore produced a review of the offshore rig market with emphasis on deepwater which gave the following results:

- 100% utilisation and fleet commitment through 2006 and 2007
- Increasing back-log
- New equipment contracted until late 2009



Contract Status and Expected Demand 1997 to 2009 for Deepwater Drilling Units (>3,000feet)

A global shortage of deepwater drilling rigs

Five wells in 86 days (excluding mobilisation).

Two gas discoveries - Fortuna & Lykos.

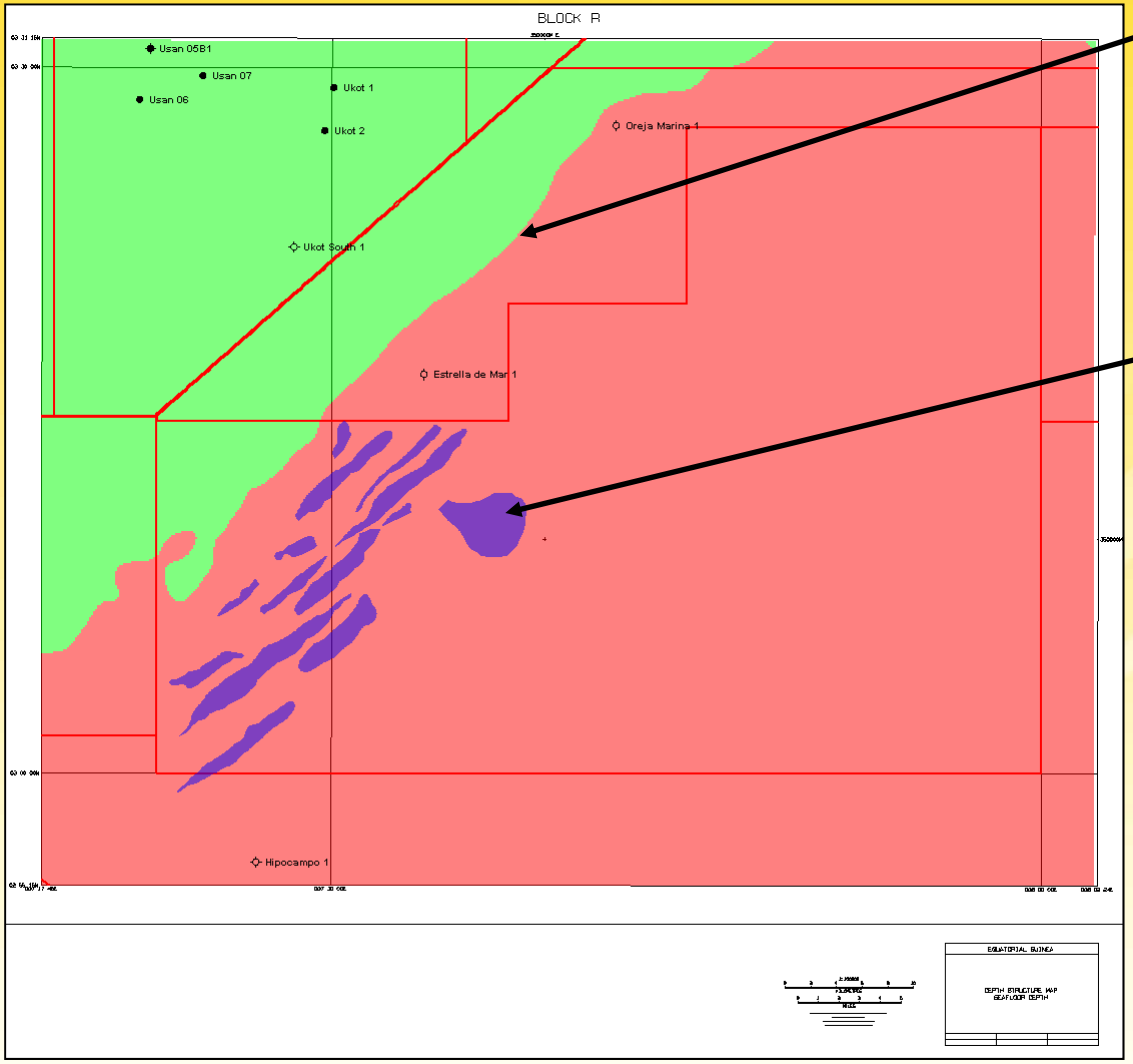
First use of Surface Blow Out Preventer ("SBOP") on drillship.

SBOP extends water depth range from 1,200 m to in excess of 1,800m

Loading Surface Blow Out Preventer onto drillship Deep Venture, Gabon, October 2008

Limited Rig capability – Deep Venture 1280m water depth

Equatorial Guinea: Block R

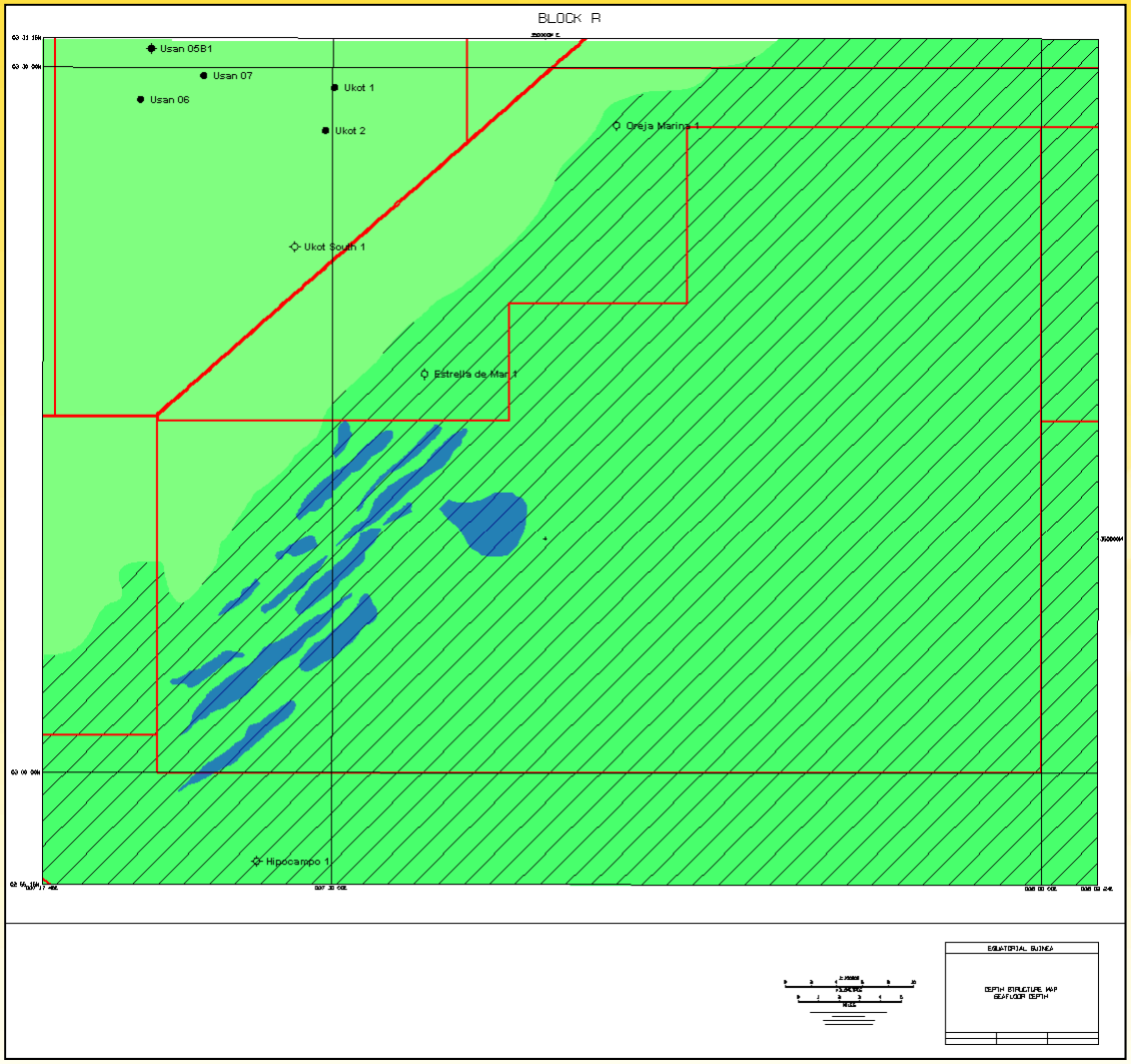


Deep Venture water depth capability

Too deep for Deep Venture

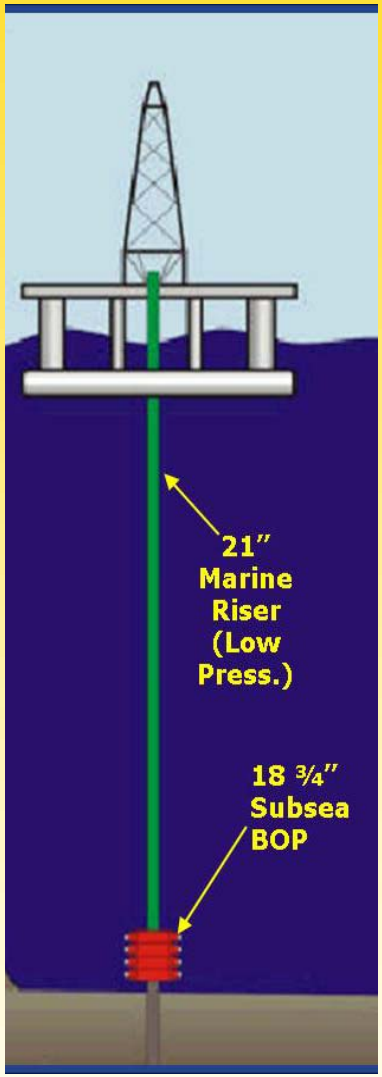
Deep Venture Water Depth Capability

Equatorial Guinea: Block R



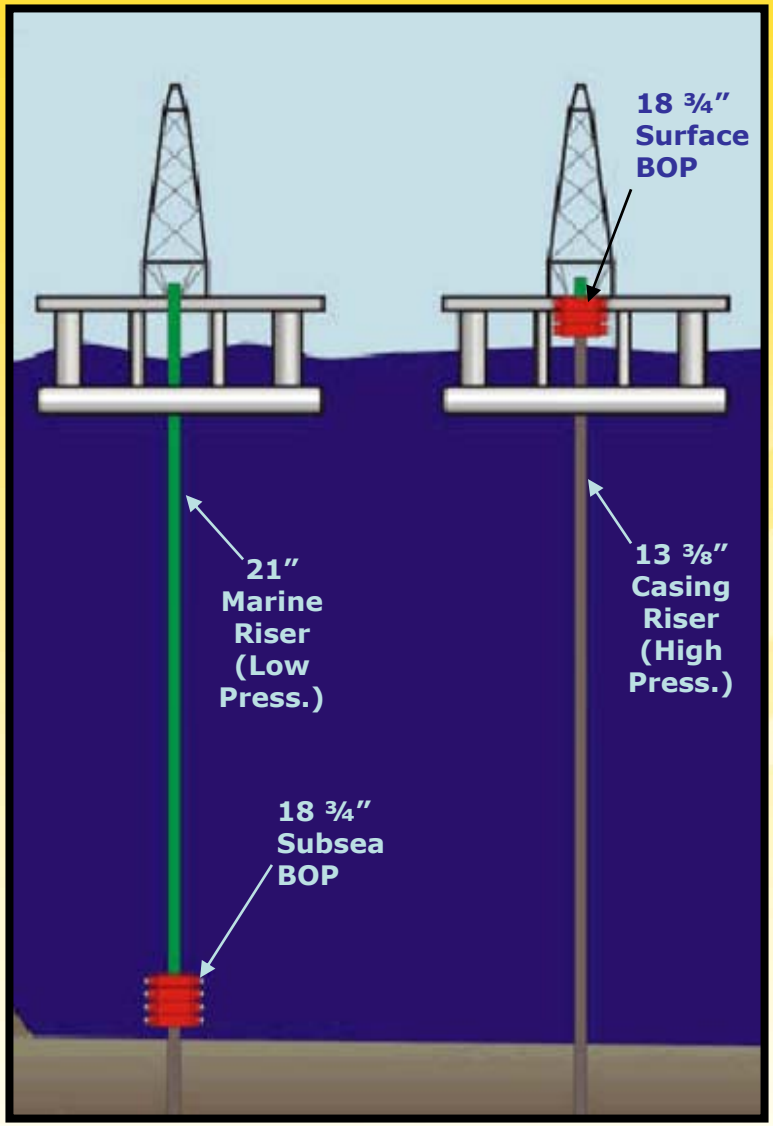
100% of prospects now accessible with Surface BOPs

Deep Venture Water Depth Capability



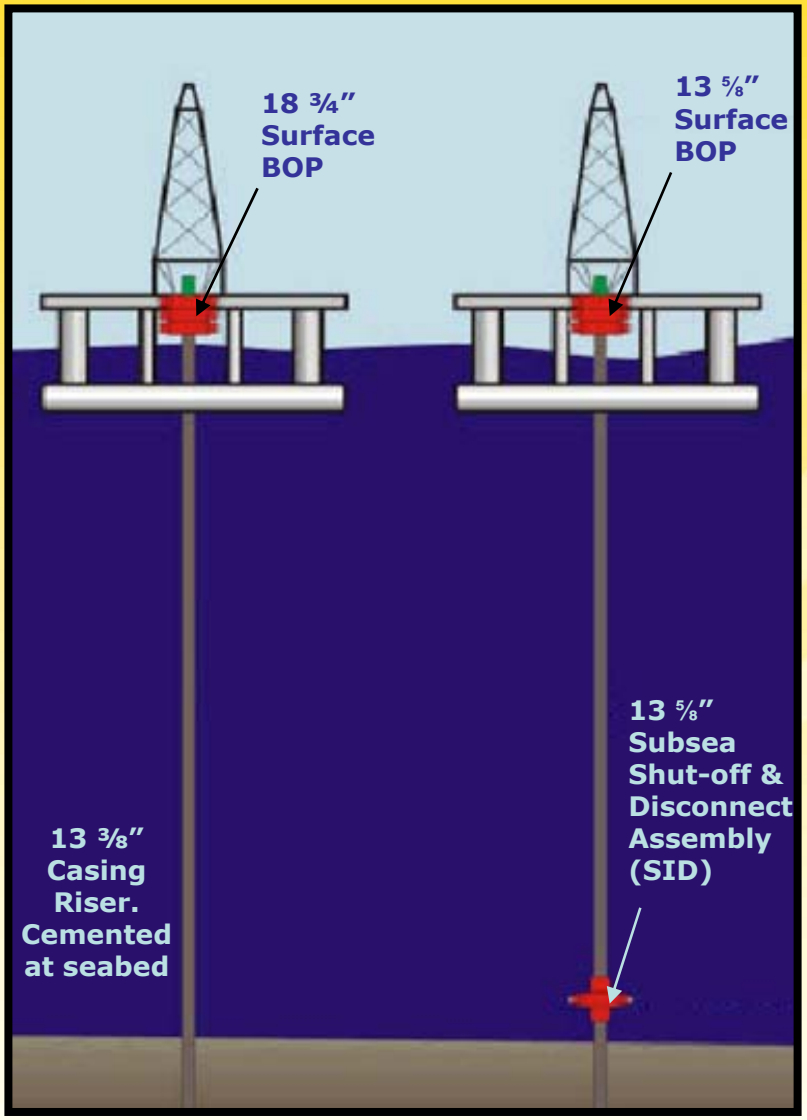
- Large ID 18¾" Subsea BOP.
- Weight about 200 to 300t.
- Large ID low pressure riser normally needs buoyancy in deepwater.
- Well control via choke and kill lines on outside of riser.
- Need large deck space and ability to hold riser.

Conventional Subsea BOPs



- In 1995 Unocal started experimenting with SBOPs to reduce overall drilling costs.
- 18¾" stack suspended in moon pool from riser tensioners. Casing cemented in at seabed. No emergency disconnect facility.
- Maximum water depth gradually increased with experience (from 72ft to 6,746ft).
- Third generation rigs used with pre-laid moorings.
- Limited to use in SE Asia.

History of SBOPs



- Shell modified system to include Subsea Shut-In Device (SID).
- Allows application of SBOP in harsher environments.
- Including SID allows SBOP to be used on a DP or moored vessel.
- Water depth record is 9,472ft.

Development of SBOPs

Diverter

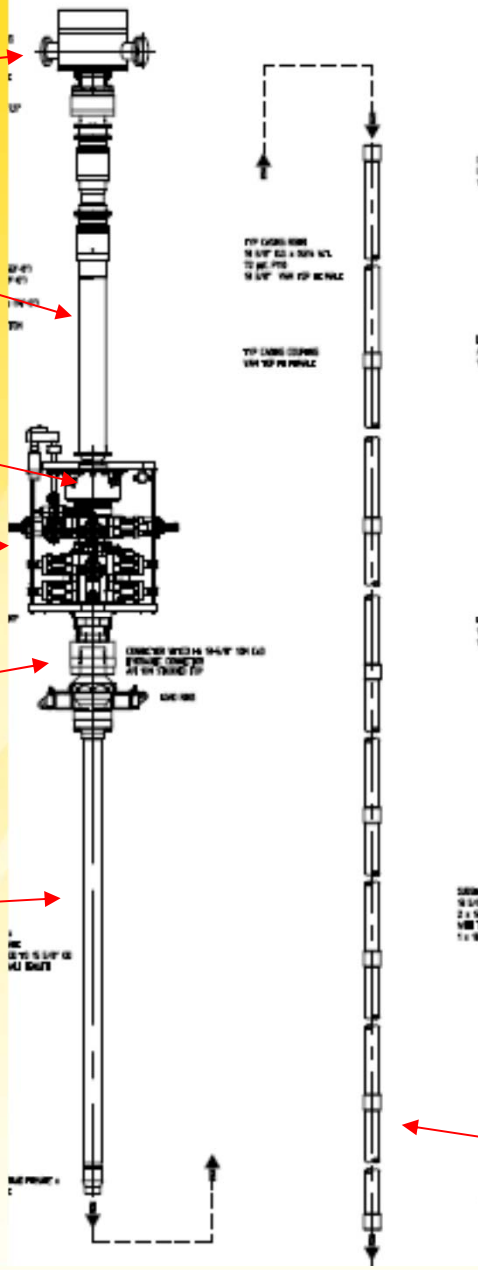
Slip Joint

13-5/8” Connector

Surface BOP

13-5/8” Connector

Stress Joint



Stress Joint

13-5/8” Connector

SID

18-3/4” Connector

Riser 13-3/8” Casing

Surface BOP Arrangement

Multiple Control Systems

i) Multiplex
ii) Acoustic
iii) ROV Intervention

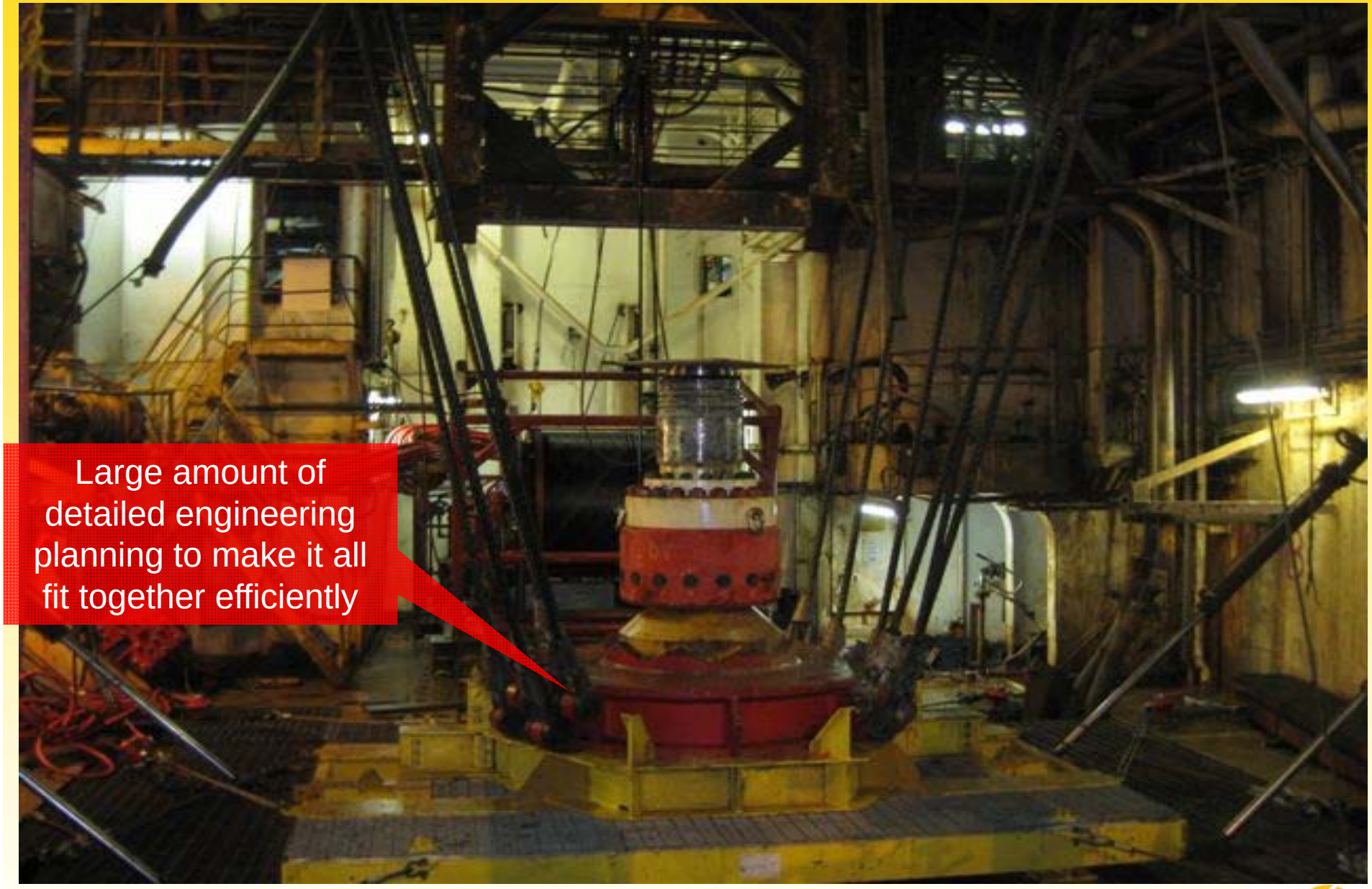
Shear Rams

$18^{3}/_{4}$" Connector

SID stored between rigs conventional BOP

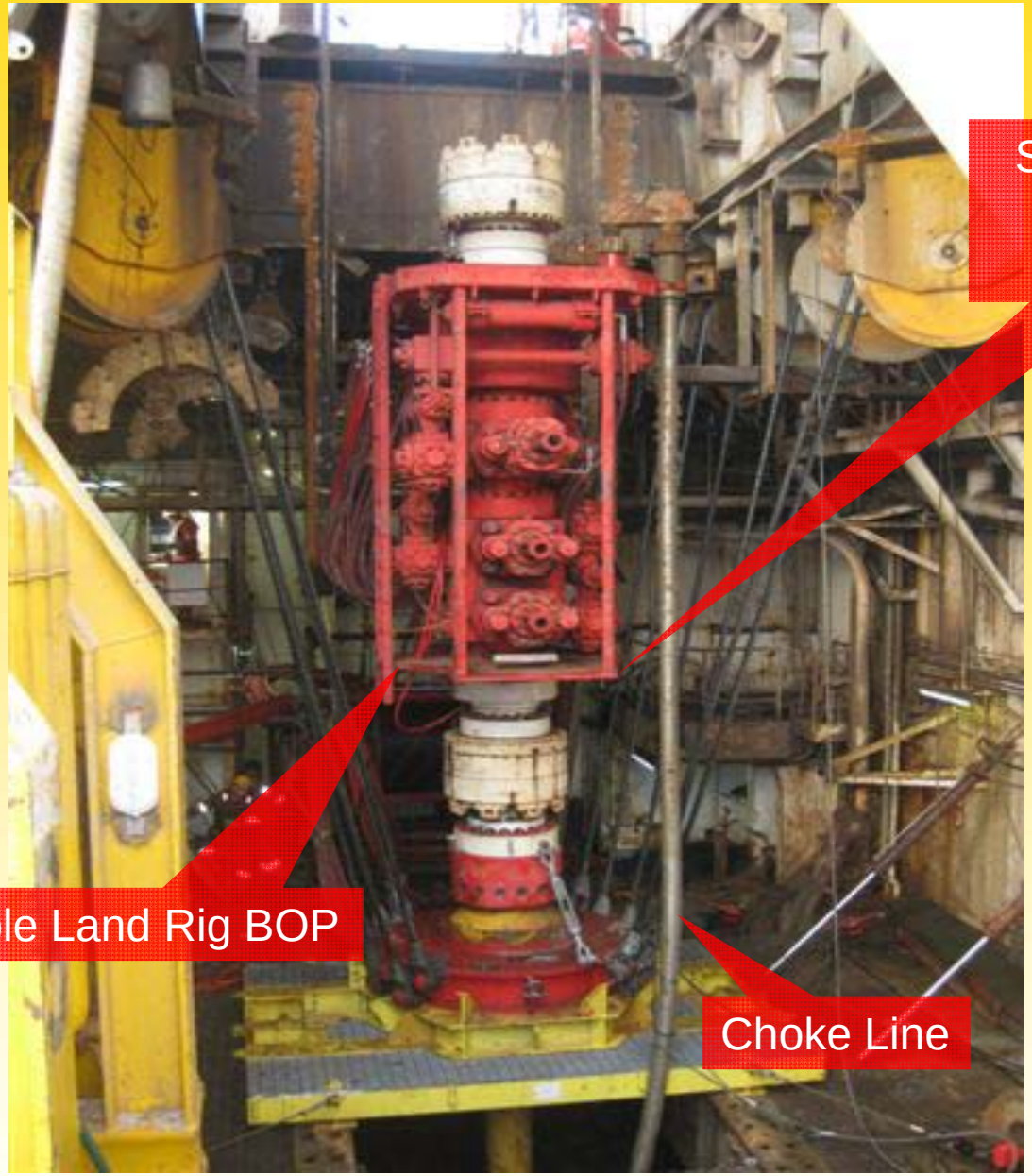
Sub-sea Shut In Device("SID")

Running SBOP: running SID into the moonpool

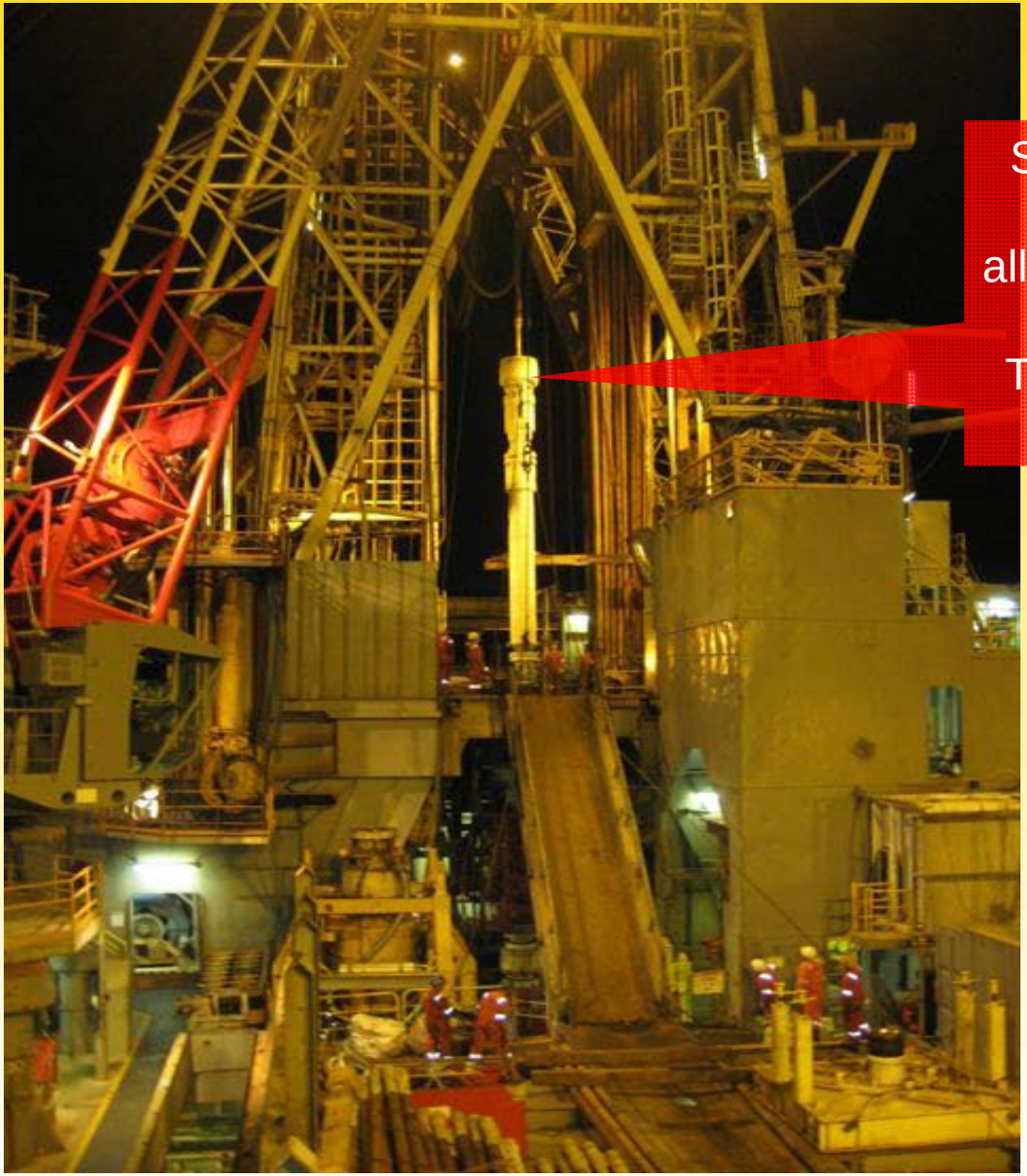


Running SBOP: preparing to run tension ring

Running SBOP: preparing to pick up SBOP



Running SBOP: landing SBOP on wellhead



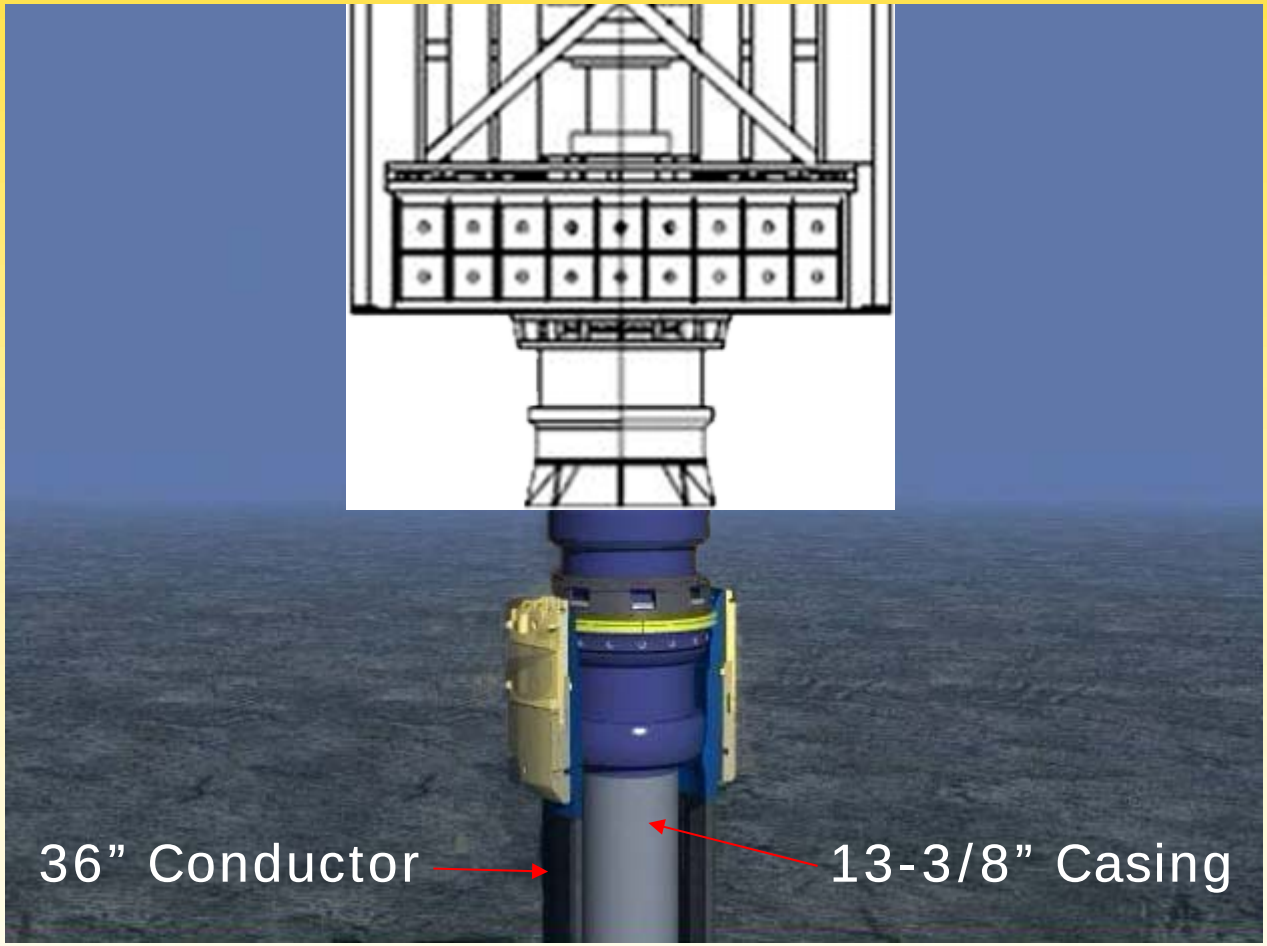
Slip Joint being installed. This allows rig to move whilst Riser Tensioners hold riser still

Running SBOP: preparing to run slip joint

Running SBOP: SBOP going underwater

SID connected to wellhead from the ROV

Running SBOP: SBOP in place in the moonpool



Conventional 18-3/4” Wellhead

Limited Casing Strings:

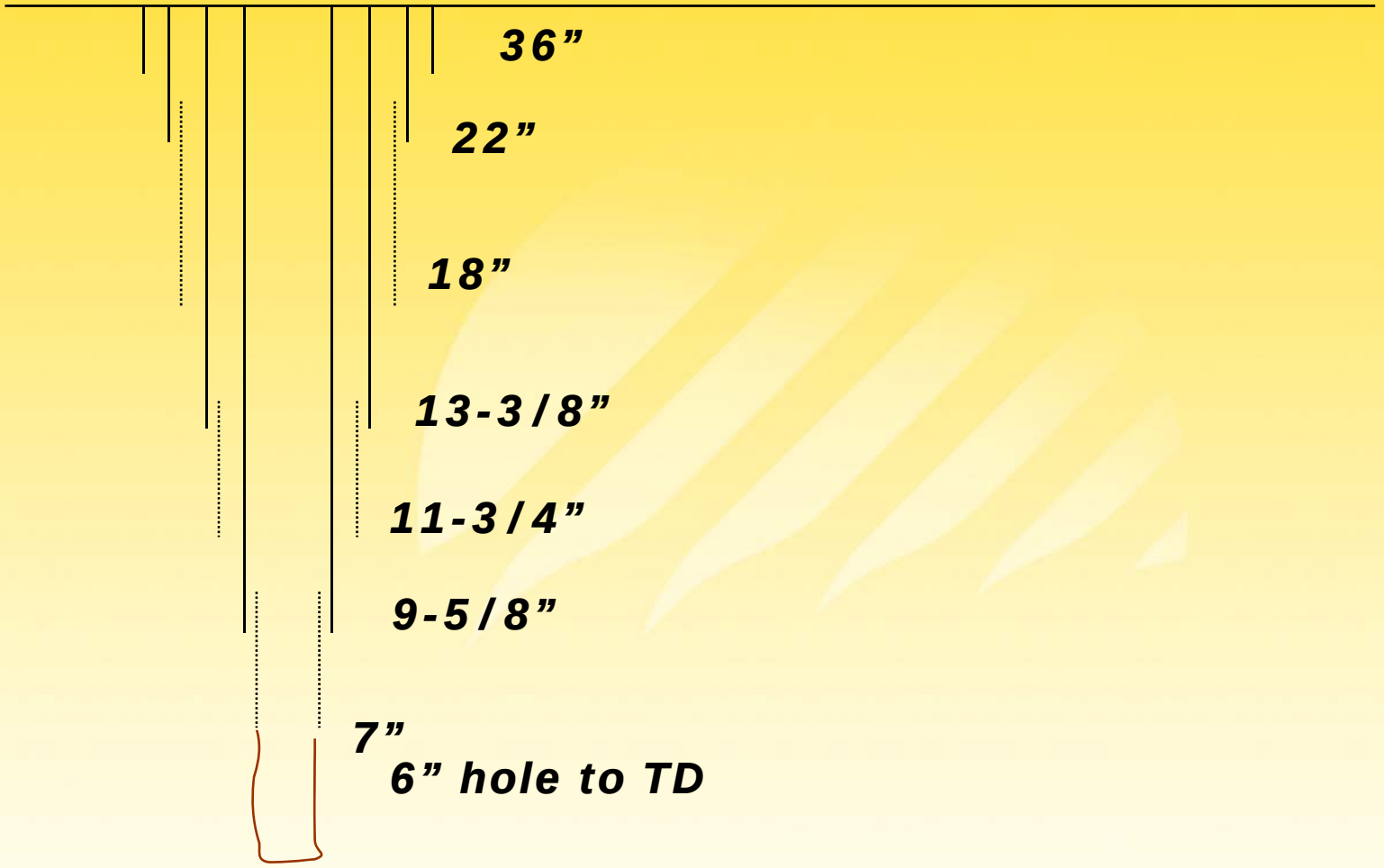
- Using 13-3/8” riser limits casing strings.
- Need to use liners.

Not suitable for deep high-pressure wells:

- Generally need more casing strings, ie hole too small.
- Surface pressure limitations of 13-3/8” (+/- 5,000psi).

Ideal for EG and Gabon

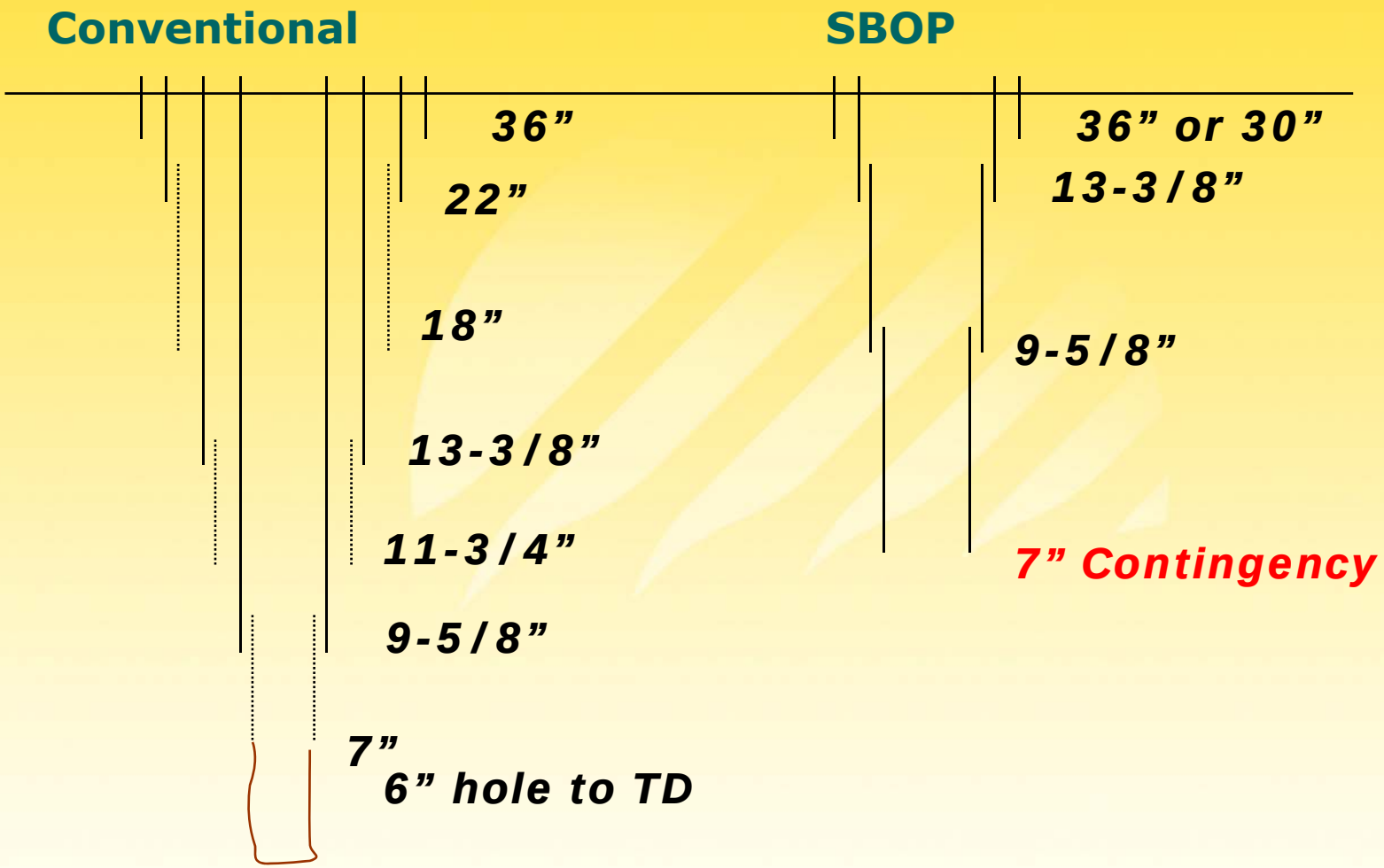
Conventional



Not to scale

Conventional Casing Design

SBOP Casing Design



Not to scale

1. Are SBOPs Safe?
2. How do you demonstrate it?

Are SBOPs Safe?

- Managed by Stena Drilling.
- Station Keeping Study to confirm the Deep Venture capability - Kongsberg, Norway.
- Riser Analysis to ensure no riser failure - 2H Offshore, Woking.
- Quantitative Risk Assessment - IRC, Houston.
- Equipment Running Capabilities and Procedures - Stena Drilling/LOG.
- Pore Pressure Studies KSI Perth/Houston.

- Study Performed by Kongsberg.
- No effects of adding SBOP.
- Disconnect time less than conventional Subsea BOPs.

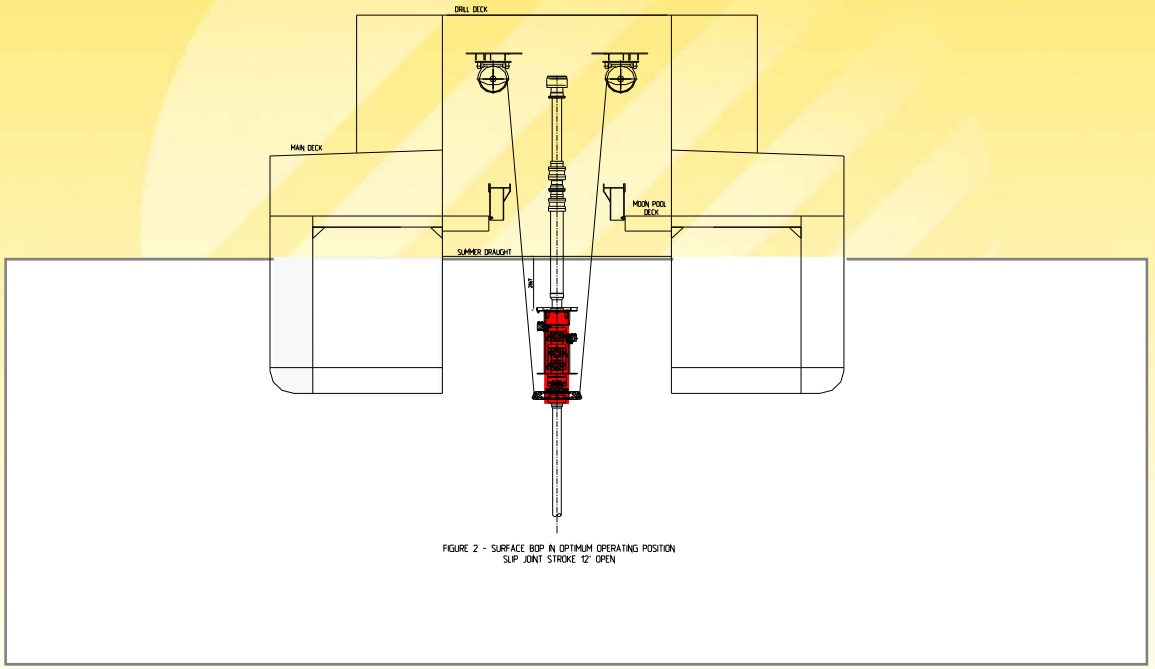


FIGURE 2 - SURFACE BOP IN OPTIMUM OPERATING POSITION
SLIP JOINT STROKE 12' OPEN

Riser Analysis 2H Offshore:

- Focus on likely fatigue life.
- Understand if VIV suppression required.
- Any wave loading issues.

Conclusions:

- Vam Top 13-3/8”- 8 year fatigue life.
- Vam Top FE - 43 year fatigue life:
  - *Ophir ran Vam Top FE riser although over designed*
  - *Fatigue life based on no VIV suppression*

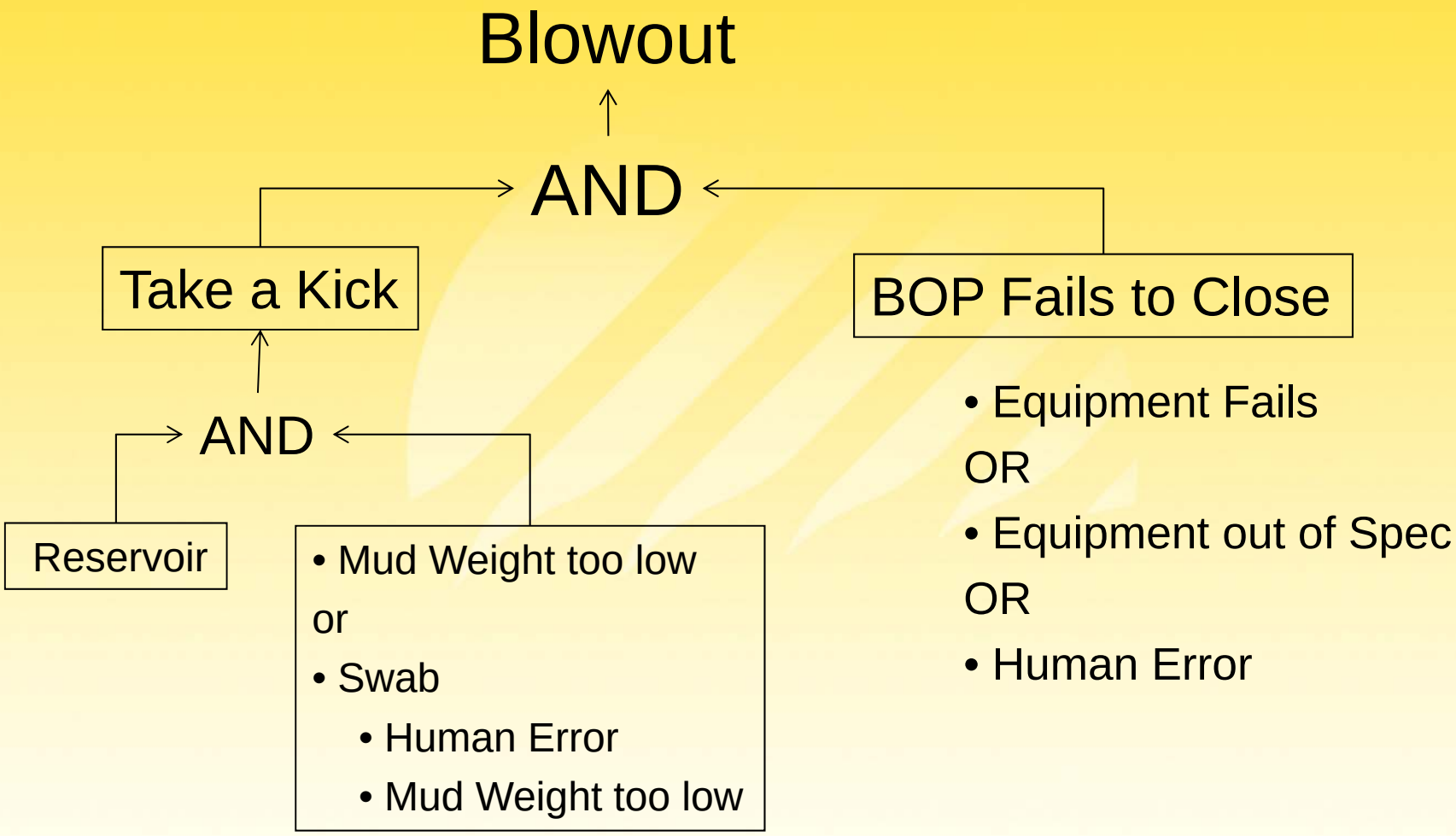
Quantitative Risk Assessment (QRA) IRC Houston

- Performed detailed QRA similar to that performed by Shell and Stena on the Stena Tay.
- Understand effect of using a dynamically positioned vessel.
- Understand if SID required.

Quantitative Risk Assessment (QRA)

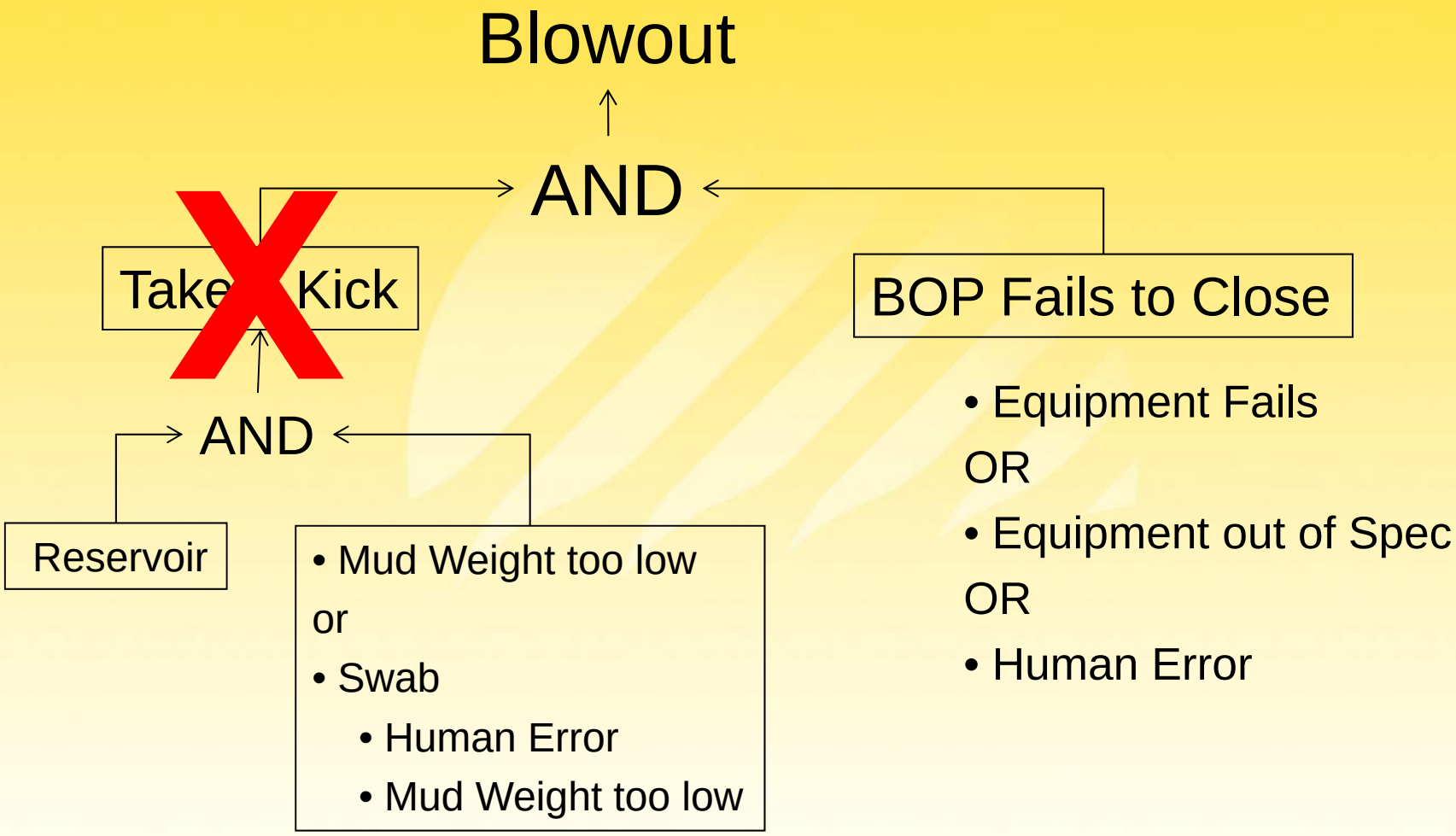
- Looks at the failure path leading to a blowout
- Describe logic leading to failure
- Apply probabilities/Frequencies to each failure point
- The result indicates the likelihood of failure
- The answer is the answer, either logic wrong or probabilities wrong but **not** the answer

Quantitative Risk Assessment (QRA)



Build Failure Tree

Quantitative Risk Assessment (QRA)



Build Failure Tree

Quantitative Risk Assessment (QRA)

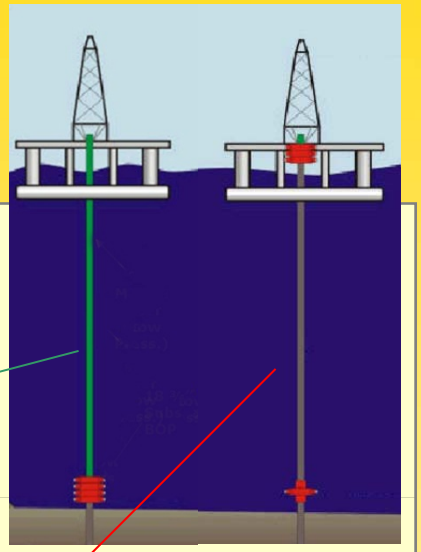
Blowout Mechanisms

- Kick and BOP Fails
- Kick and BOP Closed too late
- Riser Failure and BOP Fails
- Kick and Shoe Failure (underground blowout)
- Choke and Kill Failure and Kick

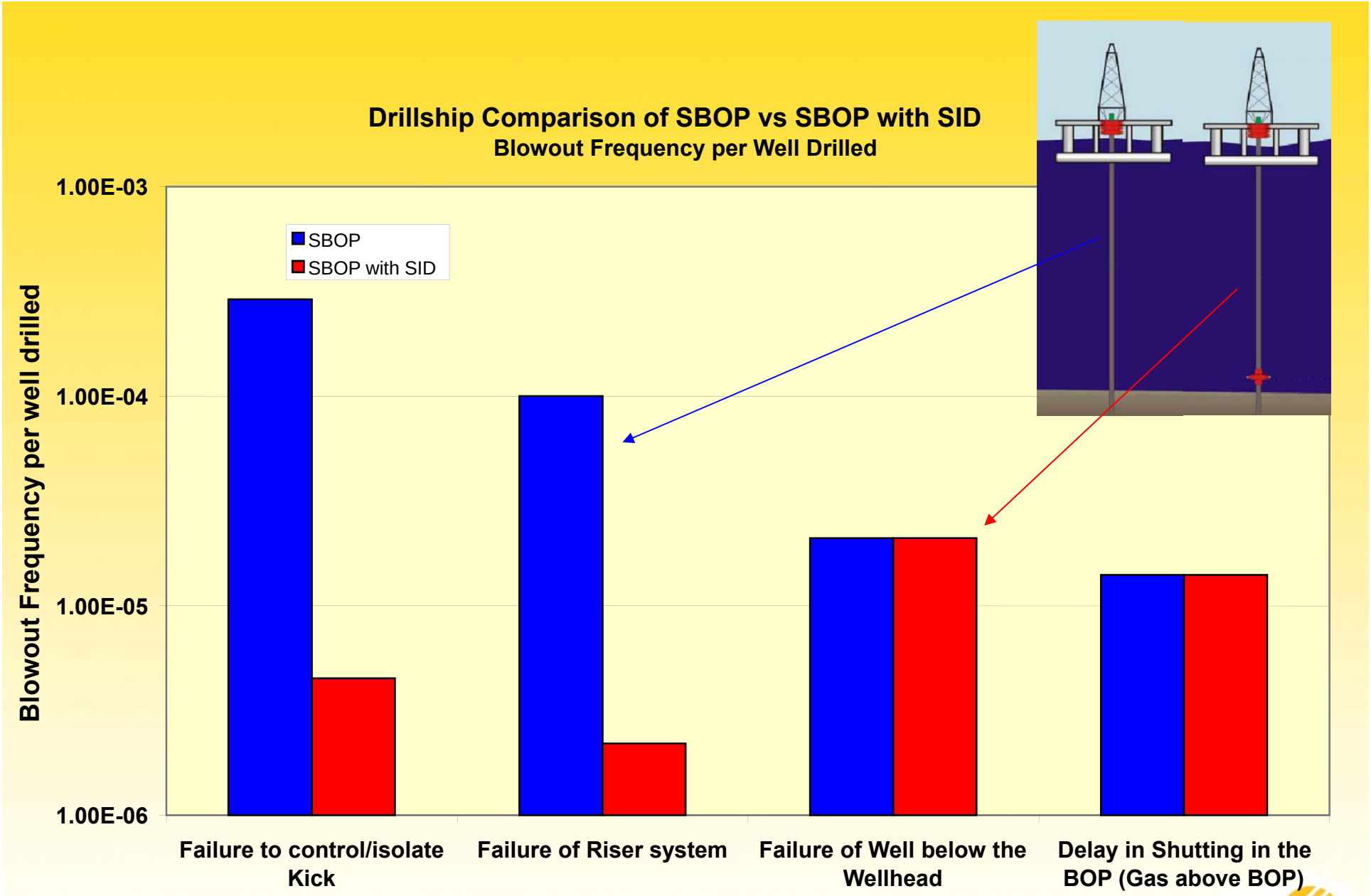
See SPE/IADC 67709

Drillship Comparison of Subsea BOP vs SBOP w/SID

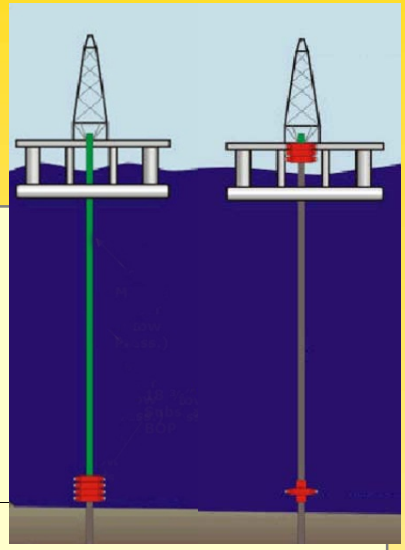
Blowout Frequency per Well Drilled



Risk Assessment Results Using SID



Risk Assessment Results



Blowout Magnitude Comparison

Are SBOPs Safe?

Absolutely, QRA suggests significantly safer than a single Subsea BOP

Provided:

1. Engineered correctly
2. Understand limitations

- Surface BOPs potentially safer than conventional Subsea BOPs:
    - Driven by essentially by having two BOPs.

SID essential on DP vessel
Recommended on moored vessel

Conclusions