Petrofac

SPE LONDON MEETINGS 2013

SUBSEA PRODUCTION AND FLOW ASSURANCE

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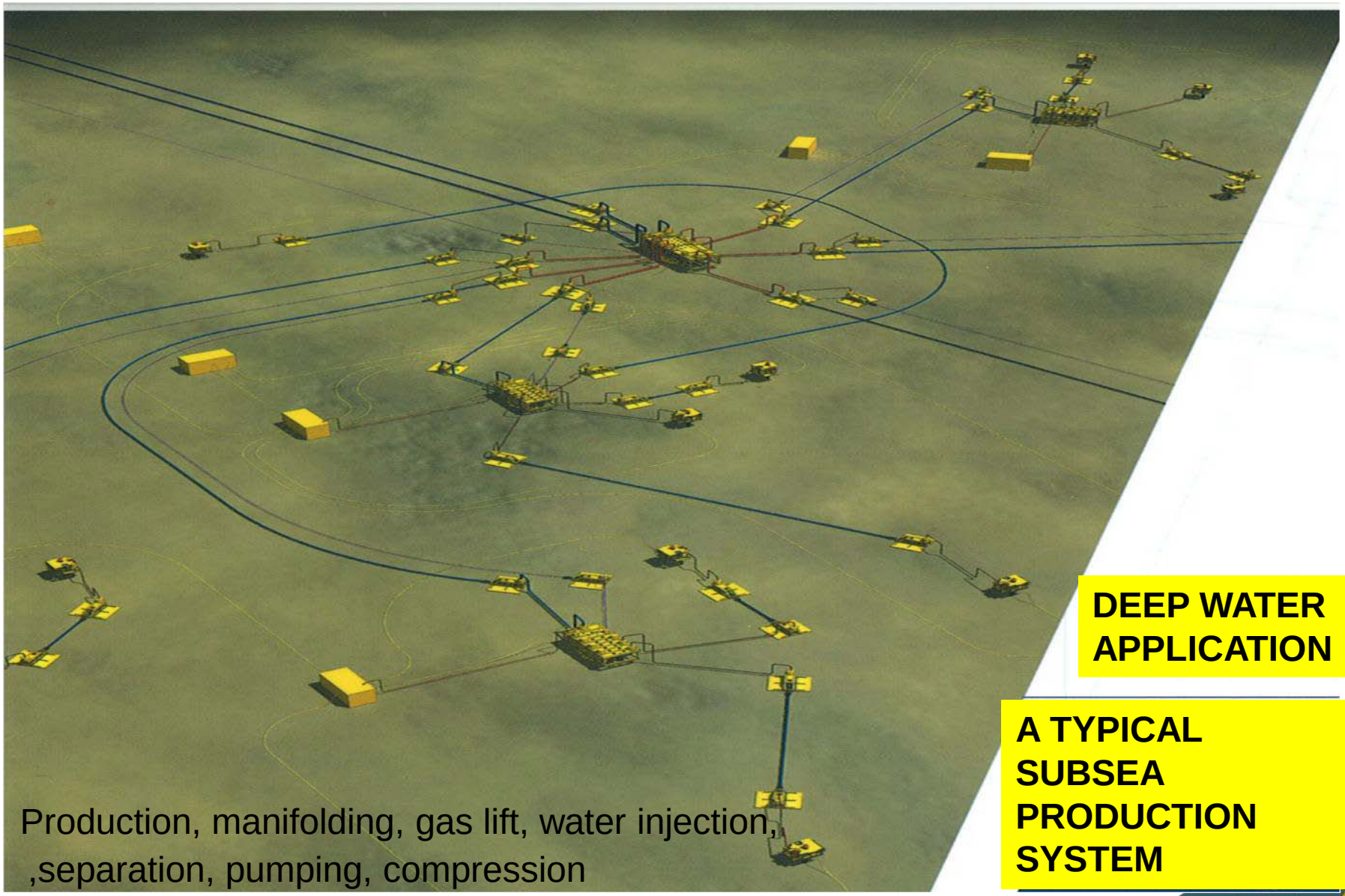
CALTEC

SUBSEA PRODUCTION &FLOW ASSURANCE

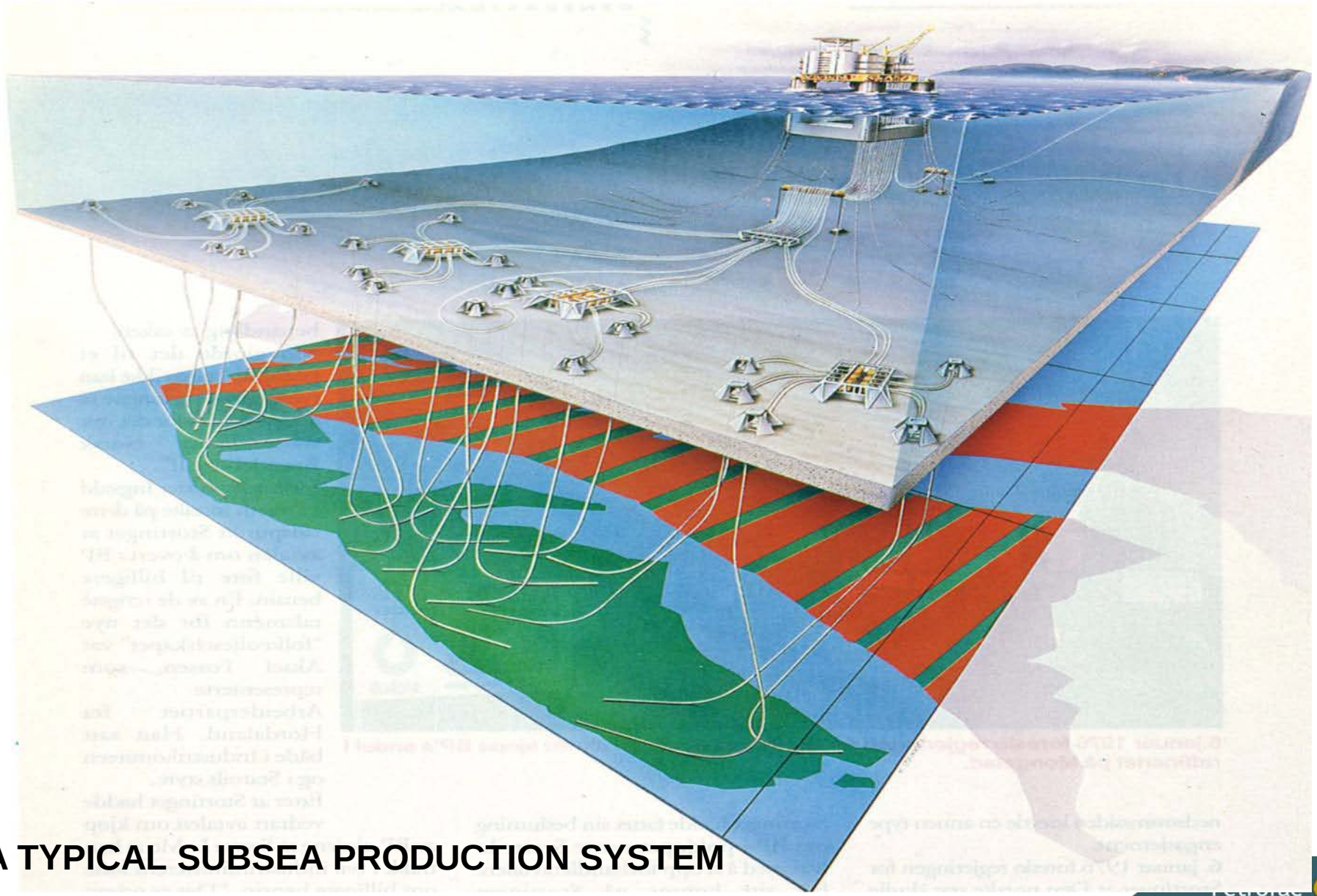
- WHY SUBSEA PRODUCTION ?
- KEY PARAMETERS
- SUBSEA PROCESSING OPTIONS
- FLOW ASSURANCE IN WELLS
- FLOW ASSURANCE IN SUBSEA PIPELINES/RISERS
- HISTORY OF SS SEPARATION & BOOSTING SYSTEMS
- FIELD EXAMPLES
- THE FUTURE NEEDS AND ASPIRATIONS
- TECHNOLOGY GAPS/CONCLUSIONS



Production, manifolding, gas lift, water injection, ,separation, pumping, compression

DEEP WATER APPLICATION

A TYPICAL SUBSEA PRODUCTION SYSTEM



A TYPICAL SUBSEA PRODUCTION SYSTEM

WHY SUBSEA PRODUCTION?,KEY PARAMETERS

- DEEP/DEEPER WATER FIELDS,HIGH COST OF MORE THAN ONE DEDICATED PRODUCTION PLATFORMS
- SHALLOW TO MEDIUM WATER DEPTH; TRANSPORT OF FLUIDS FROM SATELLITES OR NEW FIELDS TO A HOST PLATFORM
- HOSTILE ENVIRONMENTS, LONG DISTANCE TRANSPORT TO A MORE BENIGN ENVIRONMENT
- DEEP WATER/LONG DISTANCE PIPELINES, PRESSURE LOSS RESTRICTING PRODUCTION &RECOVERY+OTHER FLOW ASSURANCE PROBLEMS
- RISER GENERATED PROBLEMS

SUBSEA PRODUCTION,MAIN BENEFITS

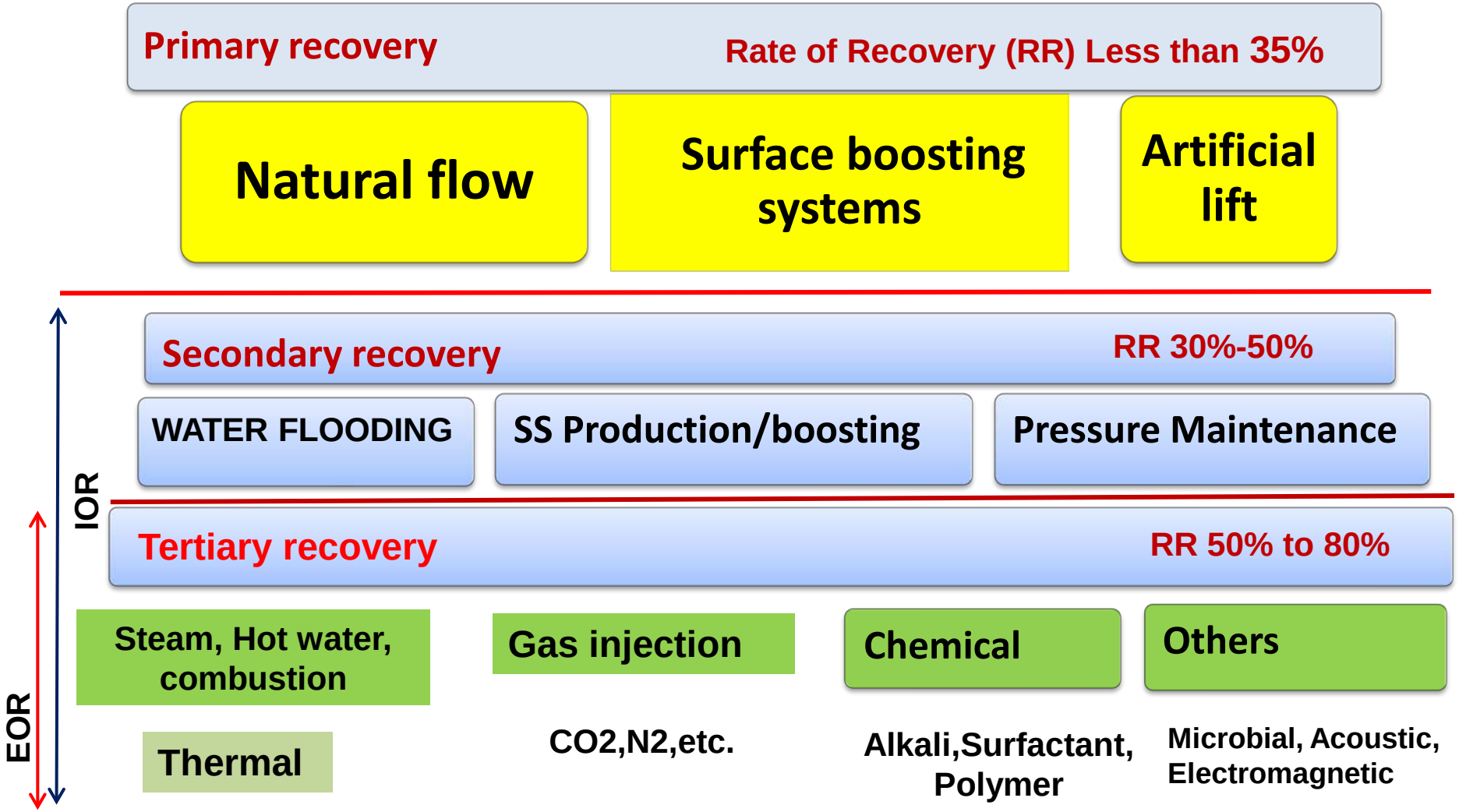
- INCREASED TOTAL RECOVERY
- ENABLING PRODUCTION FROM DEEP WATERS AND HOSTILE ENVIRONMENTS
- LOWER CAPEX/OPEX-CONVENTIONAL PRODUCTION PLATFORMS IN DEEP WATERS HAVE MUCH HIGHER CAPEX &OPEX
- ENABLES LONG DISTANCE TRANSPORT OF FLUIDS TO EXISTING HOST PLATFORMS
- HSE BENEFITS

MAIN CAUSES OF RESTRICTIONS TO PRODUCTION & TOTAL RECOVERY

- Low reservoir pressure/aging field
- Tight, fragmented resevoirs,poor Permeability /PI
- Deep reservoirs/deep wells-long flow path
- Low GOR /liquid loading
- Rising water cut
- Long distance transport (Satellites)
- High density and viscosity oil
- Poor well inflow characteristics
- Topside Process system pressure requirements
- Hostile environments ,e.g. Arctic

A boosting system is therefore needed to maintain or increase production and total recovery

HOW TO MAINTAIN PRODUCTION AND IMPROVE RECOVERY



SOLUTIONS TO MAINTAIN OR BOOST PRODUCTION AND TOTAL RECOVERY

- MAINTAIN RESERVOIR PRESSURE. E.G. WATER INJECTION
- IOR and EOR TECHNIQUES
- ENHANCE INFLOW CONDITIONS E.G. ACIDIZE/FRACKING.
- DOWNHOLE ARTIFICIAL LIFT;GAS LIFT,ESPS, FOAM INJECTION ETC. PROBLEMS OF HORIZONTAL WELLS
- SUBSEA PRODUCTION &BOOSTING-DEEP OR HOSTILE WATERS
- EXTENDED REACH HORIZONTAL WELLS
- LOWER FLOWING WELLHEAD PRESSURE (FWHP)-VARIOUS METHODS ,INCLUDING SURFACE JET PUMP (SJP)SYSTEMS

SOLUTIONS DICTATED BY ECONOMICS ,RISKS AND FIELD/PLATFORM CONSTRAINTS.

Combined solutions are often needed

PRODUCTION FLOW PATH

RESERVOIR	WELL BORE	WELLHEAD	PIPELINE	MANIFOLD
IOR/EOR 4D- SESMICS	-ARTIFICIAL LIFT -EXTENDED REACH - FLOW ENHANCING SOLUTIONS	-XMAS TREE -INJECTION SYSTEM	-PRESSURE LOSS - FLOW REGIME/SLUGS -TEMPERATURE -CORROSION -EROSION -NASTIES;WAX,SCALE..,ETC -PIPELINE INTEGRITY	-CONNECTORS -VALVES -INSTRUMENTS -METERING -FRAME

SS BOOSTING	PIPELINE	SLUG CATCHER	RISER	TOPSIDE PROCESS	EXPORT
-MPH PUMPS -SS SEP`N+ PUMP. -GAS COMPRESSION	AS ABOVE	-SLUG CATCHER -L.PUMPING	-SLUGGING -DP -INTEGRITY	-PROCESS -BOOSTING SYSTEMS	-PUMPING COMP`N

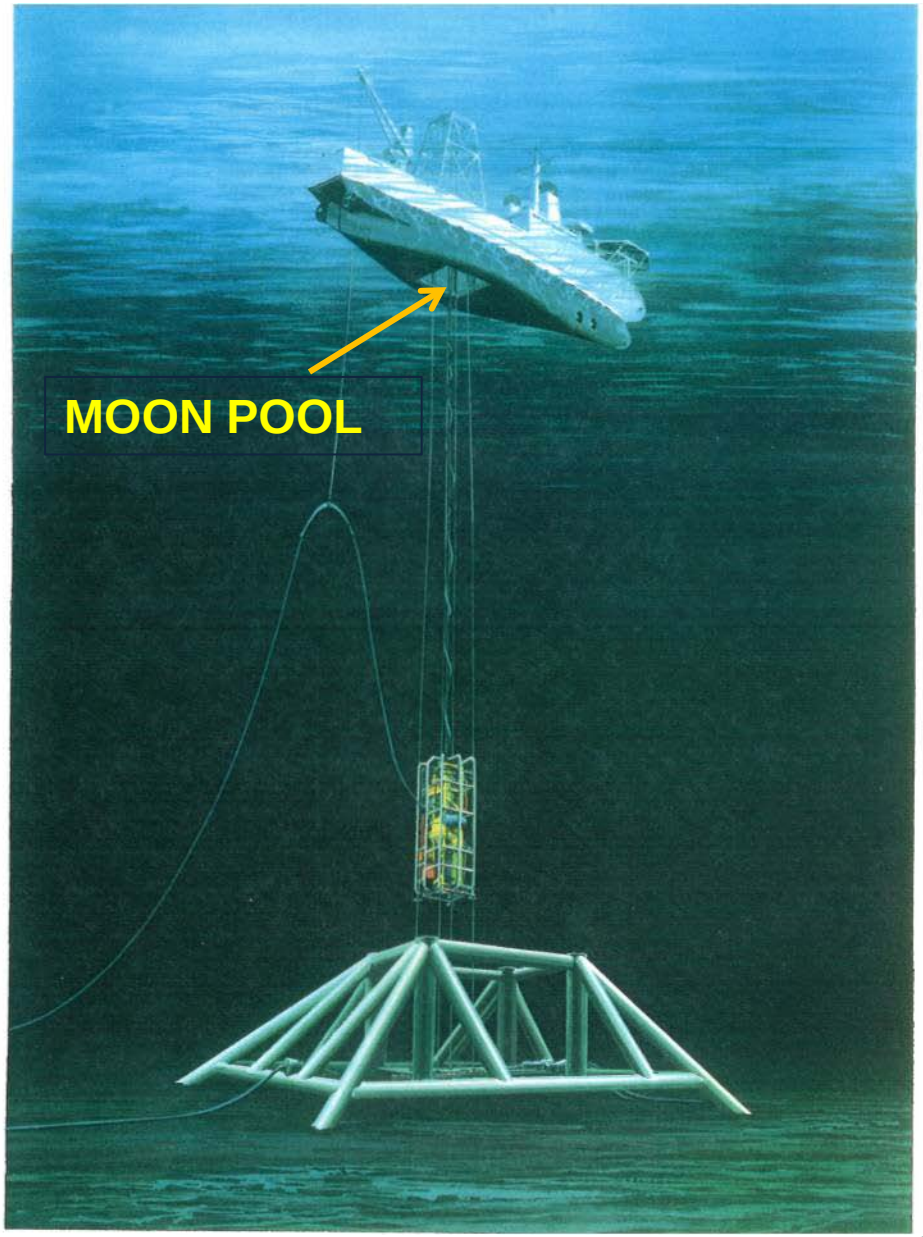
COMMON SS COMPONENTS/ISSUES

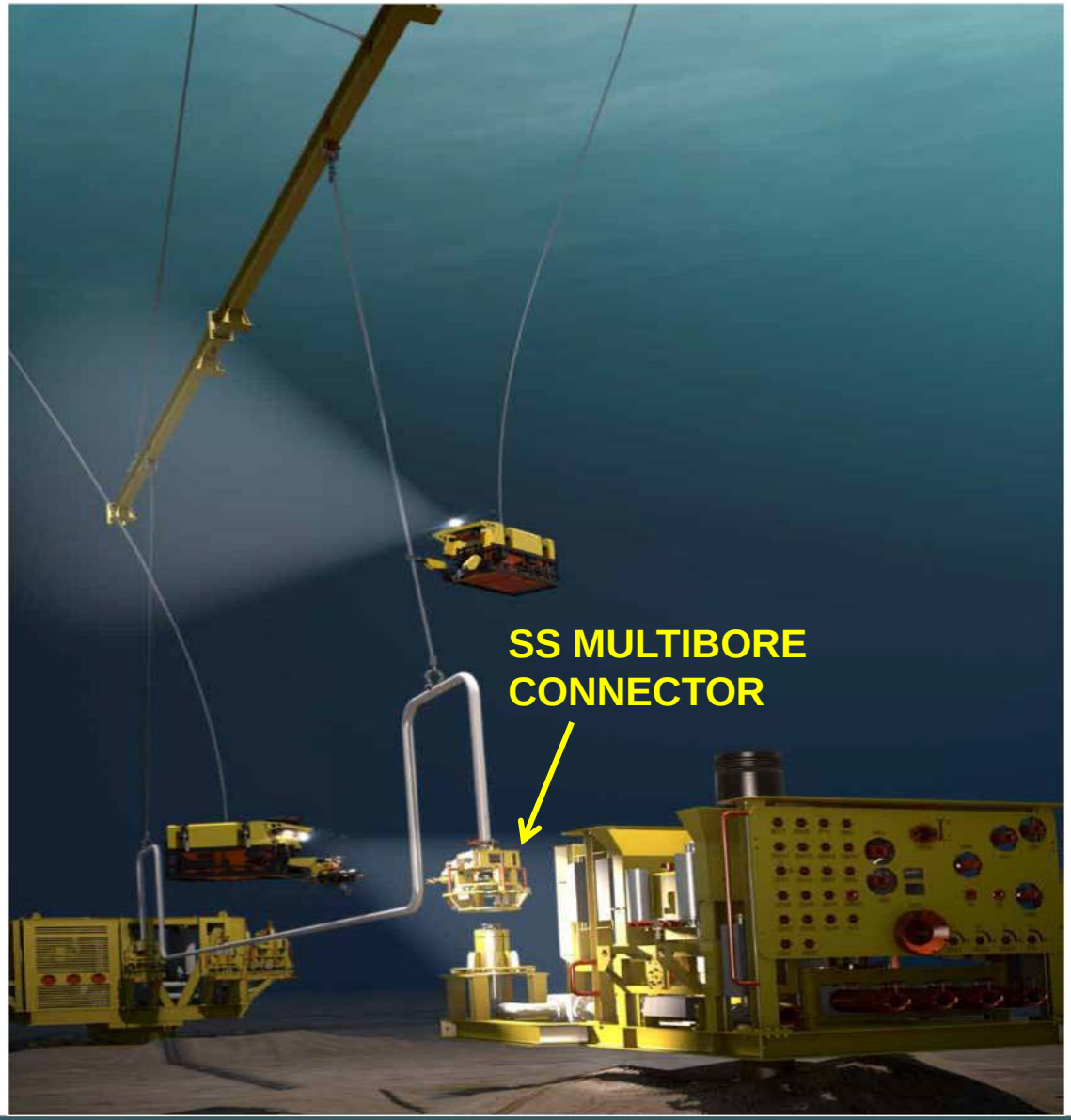
- MODULARISATION
- CONNECTORS
- INSTRUMENTS
- POWER SUPPLY (ELECTRIC,EH,HYDRAULIC)
- DATA TRANSMISSION
- ACCESS
- IMR/SERVICE VESSEL REQUIREMENTS

MODULARISATION

An artist's view of the subsea switch-gear concept in the fully connected service position. One of the control modules is shown being replaced. Figure courtesy of Schneider Electric and OceanWorks.

SUBSEA TEMPLATE AND MODULES INSTALLATION AND RETRIEVAL

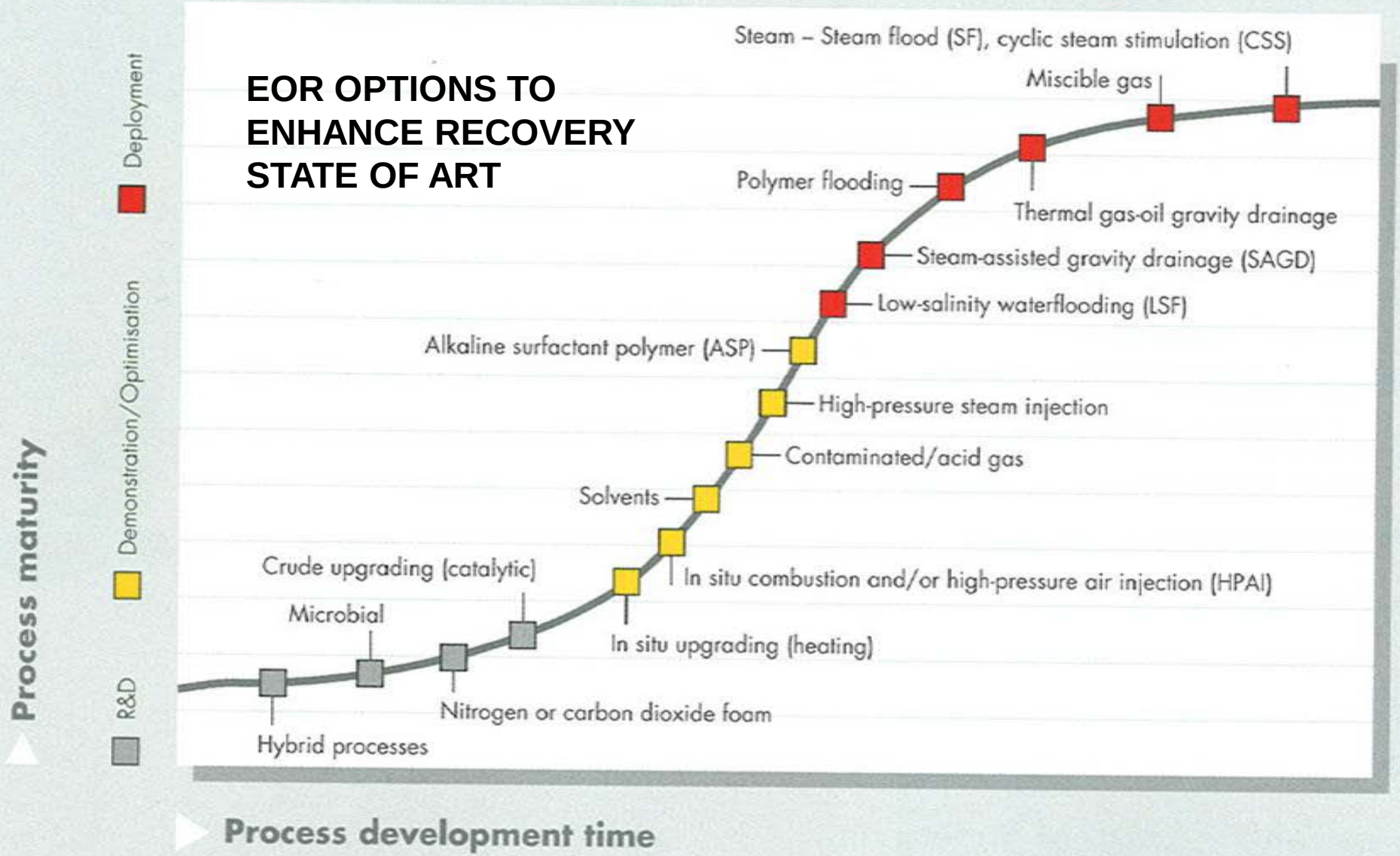




MULTI-BORE
SS CONNECTOR

KEY FEATURES;
- **MULTIBORE**
- **SEALS**
- **ACTUATORS**
- **ELECTRIC/HYDRAULIC POWER**
- **SHOULD BE RETRIEVABLE**
- **SEALS IN RETRIEVABLE PART**
- **PURGING FEATURE**
- **HORIZONTAL OR VERTICAL**

EOR OPTIONS TO ENHANCE RECOVERY STATE OF ART



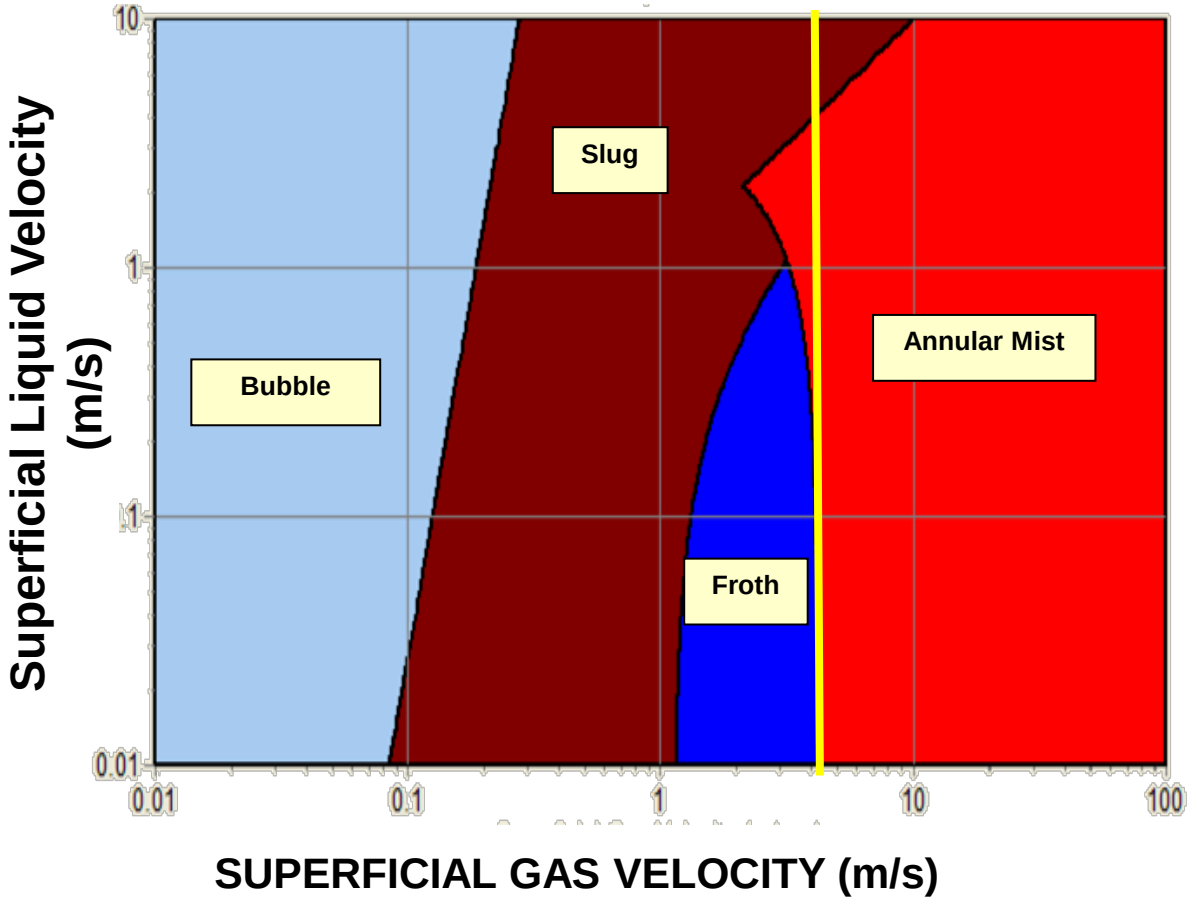
Shell's technology programme includes various initiatives at different stages of maturity. Basic research is ongoing in areas such as in situ combustion and the use of solvents; we are working with our venture partners on pilot trials and demonstration projects in Russia, Malaysia and the Middle East; and we are conducting full-scale projects in some of our mature assets across the world

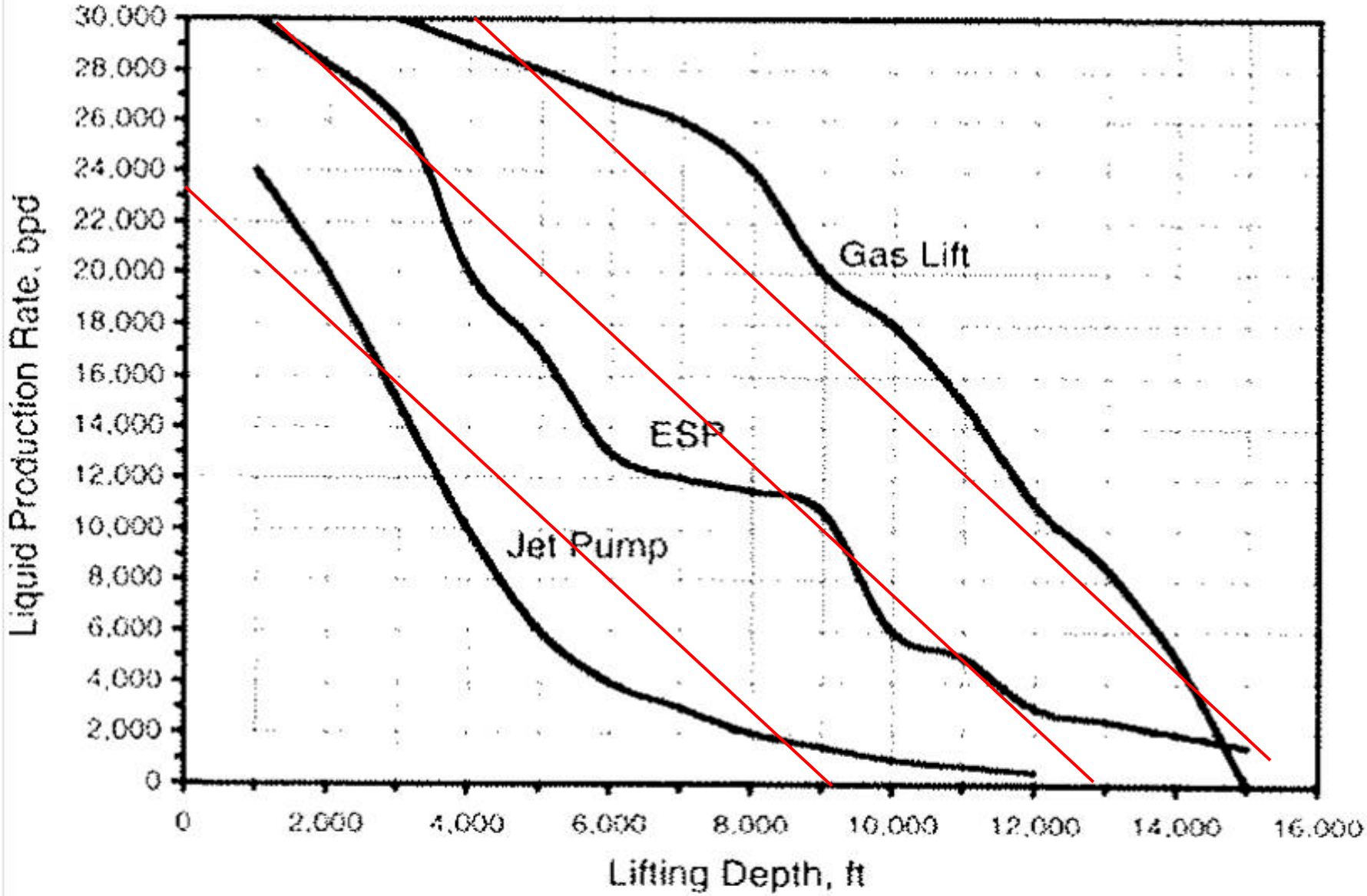
WELL BORE FLOW ASSURANCE

- MINIMISE PRESSURE LOSS
- FLOW REGIME /PREVENT LIQUID LOADING
- PROBLEM OF HORIZONTAL WELLS
- ARTIFICIAL LIFT SOLUTIONS (ESP,JET PUMP,GAS LIFT,FOAM, ETC.)
- VELOCITY STRING (GAS APPLICATION)
- CHEMICALS-SALINITY REDUCING,VISCOSITY REDUCING ETC.
- REDUCE WELLHEAD PRESSURE

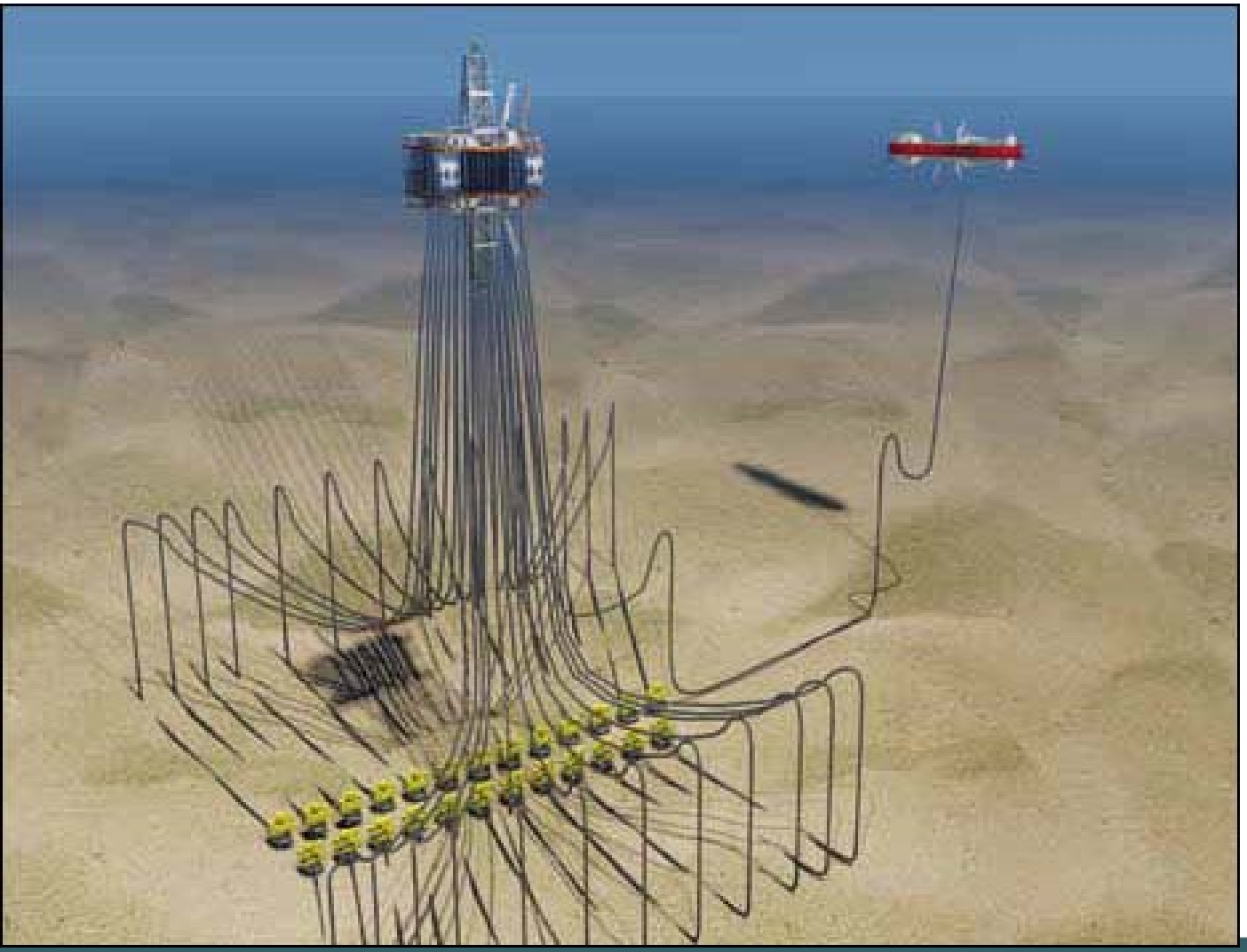
WELLBORE, FLOW REGIME MAP

- ARTIFICIAL LIFT METHODS
- GAS LIFT
- ESPs
- CHEMICAL INJECTION(FOAM)
- VELOCITY STRING (GAS)
- JET PUMPS




Liquid Production Rate, bpd
30,000
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
Lifting Depth, ft
Gas Lift
ESP
Jet Pump

SUBSEA LIUHUA FIELD ,S-CHINA SEA



25 SS ESPs IN OPERATION FOR NINE YEARS

FLOW THROUGH SS PIPELINES

- PRESSURE LOSS (H.HEAD+FRICTION)
- FLOW REGIME,SLUGGING,LIQUID BUILD-UP
- TEMPERATURE/HYDRATES
- NASTIES; SAND,SCALE,WAX,ASPHALTENE ETC
- CHEMICALS,INHIBITORS,DRA, ETC.
- PIGGING REQUIREMENTS
- CORROSION/EROSION
- PIPELINE INTEGRITY
- METERING

PRESSURE&TEMPERATURE PROFILE FOR GAS LINE

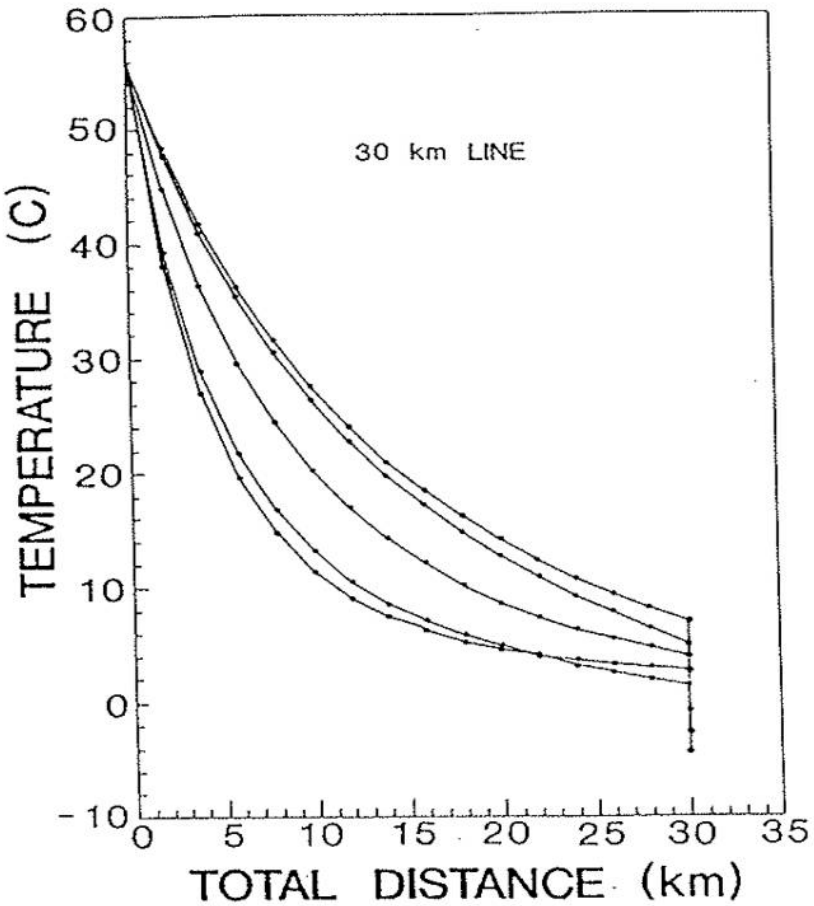


FIG 4. TEMPERATURE PROFILE ALONG THE GAS EXPORT LINE FOR VARIOUS FLOW RATES

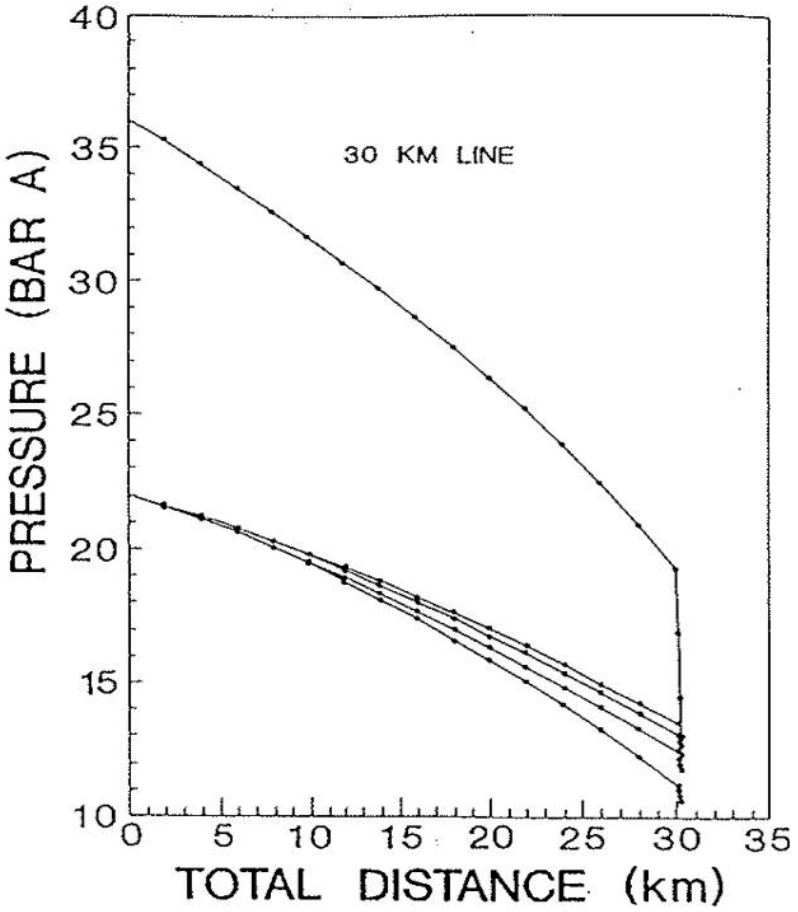


FIG 5. TYPICAL PRESSURE PROFILE ALONG THE GAS EXPORT LINE FOR VARIOUS FLOW RATES AND UPSTREAM PRESSURES

EFFECT OF TURN DOWN IN GAS RATE

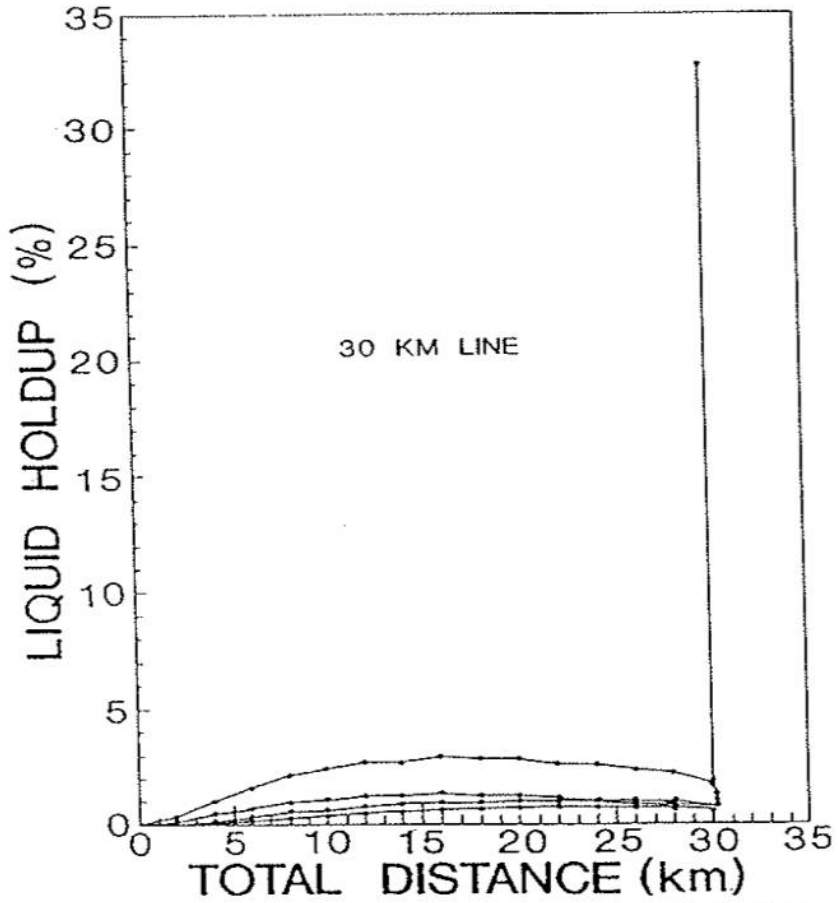


FIG 6. LIQUID HOLD-UP IN GAS EXPORT LINE FOR DIFFERENT FLOW RATES (CASES 1 TO 4)

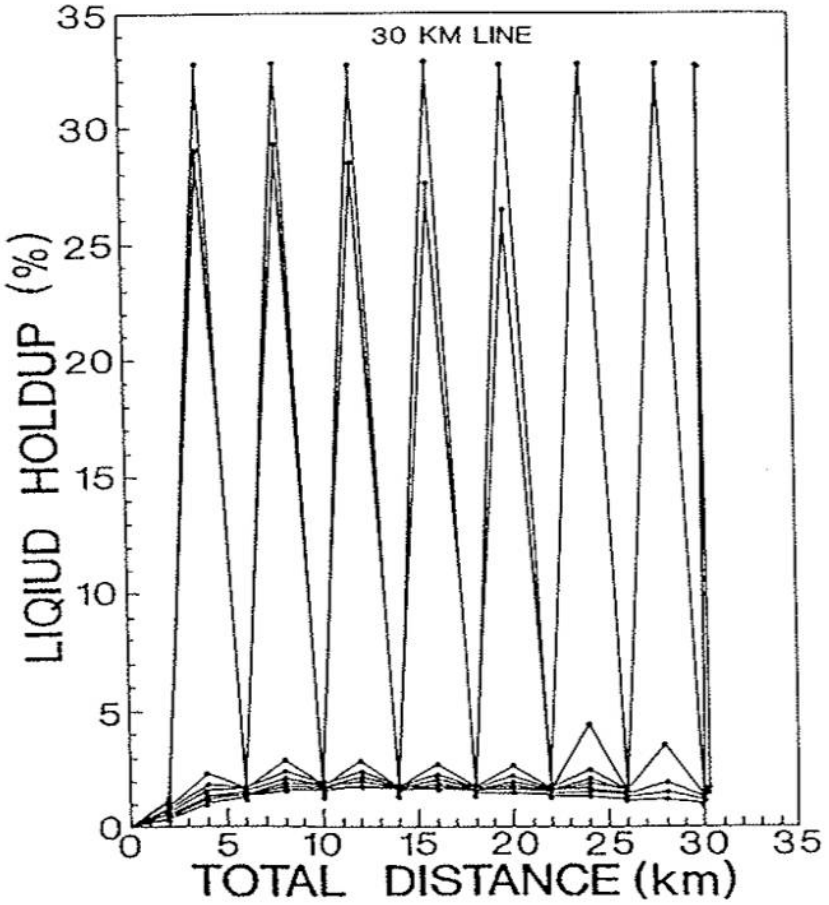


FIG 7. LIQUID HOLD-UP IN GAS EXPORT LINE FOR TURN-DOWN RANGE OF 90 % TO 10% OF FULL FLOW RATE

Chevron, USA (GOM)

Solution ; HP gas from the existing compressor on recycle used to power the jet pump (Php/Plp=4.9.Qhp/Qlp= 2.11,Pd/Plp=2)

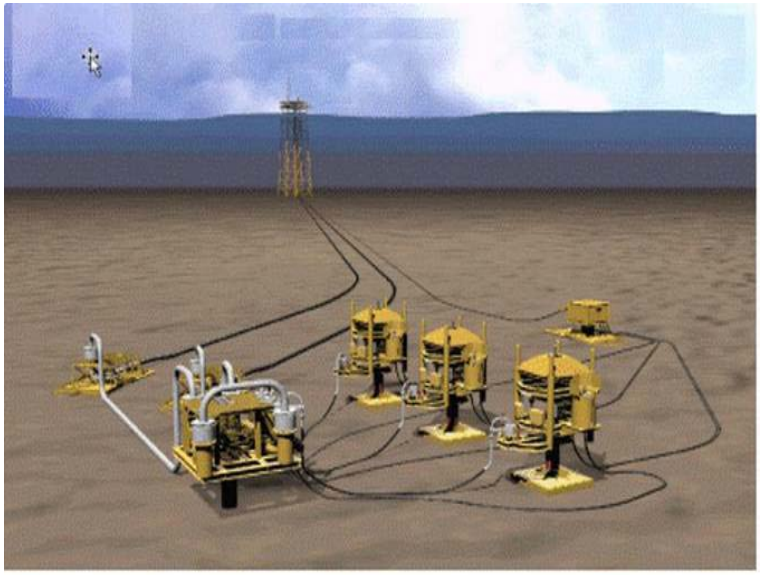
Benefits

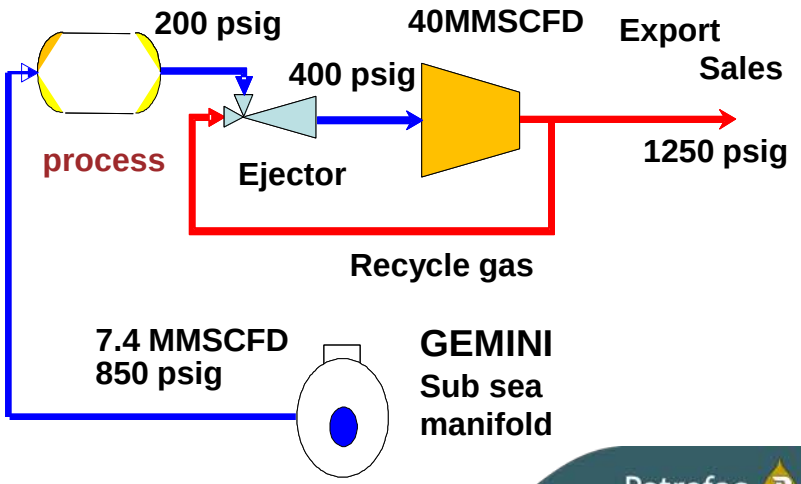
Lowered arrival pressure at the platform by 200 psi enabling loaded wells to produce consistently

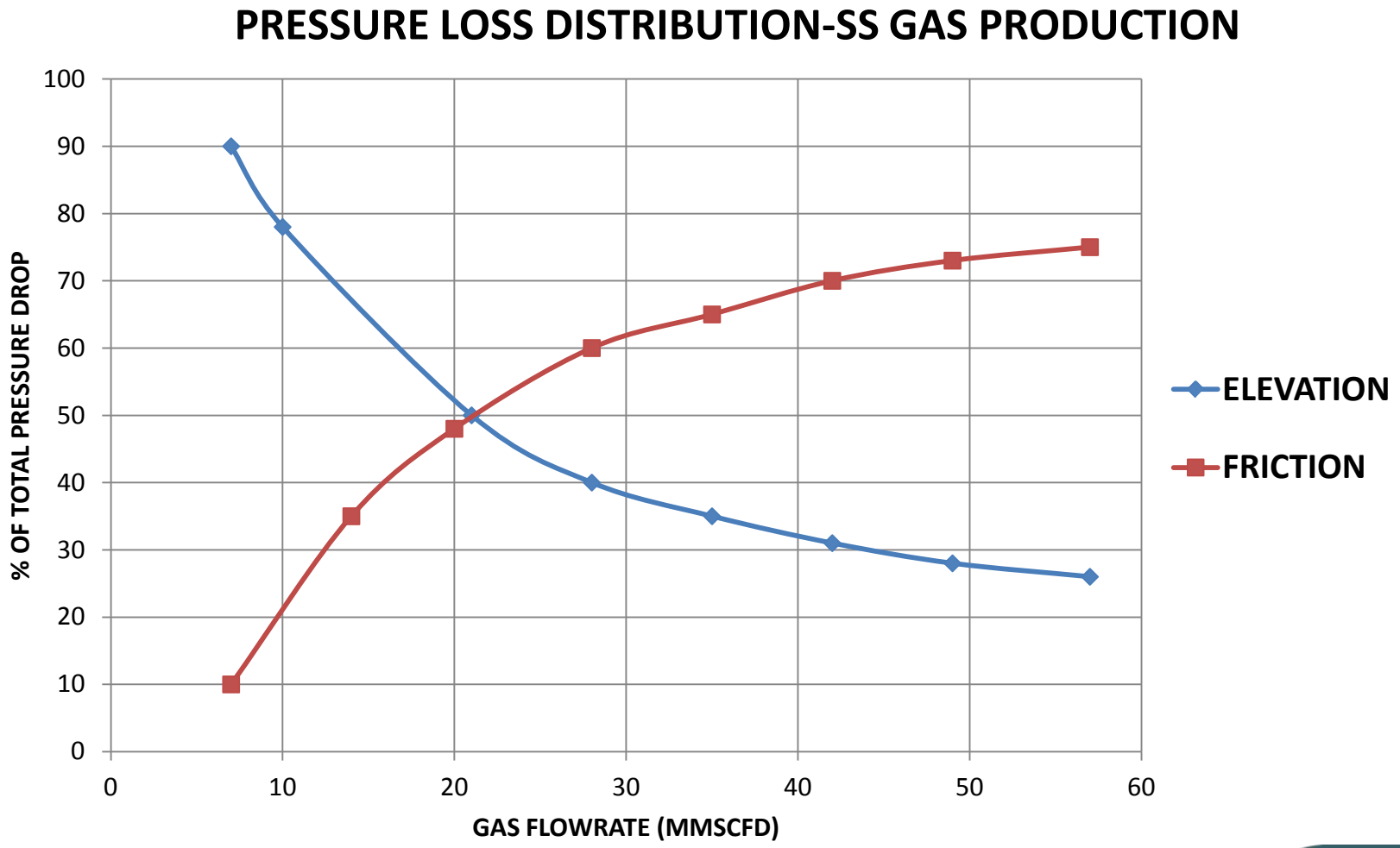
- **Higher gas velocities, lowered liquids accumulated in the pipeline, causing a further 140psi drop at the wellhead**

- **Production increased by 24% due to wellhead pressure reduction and lower pipeline loss.**

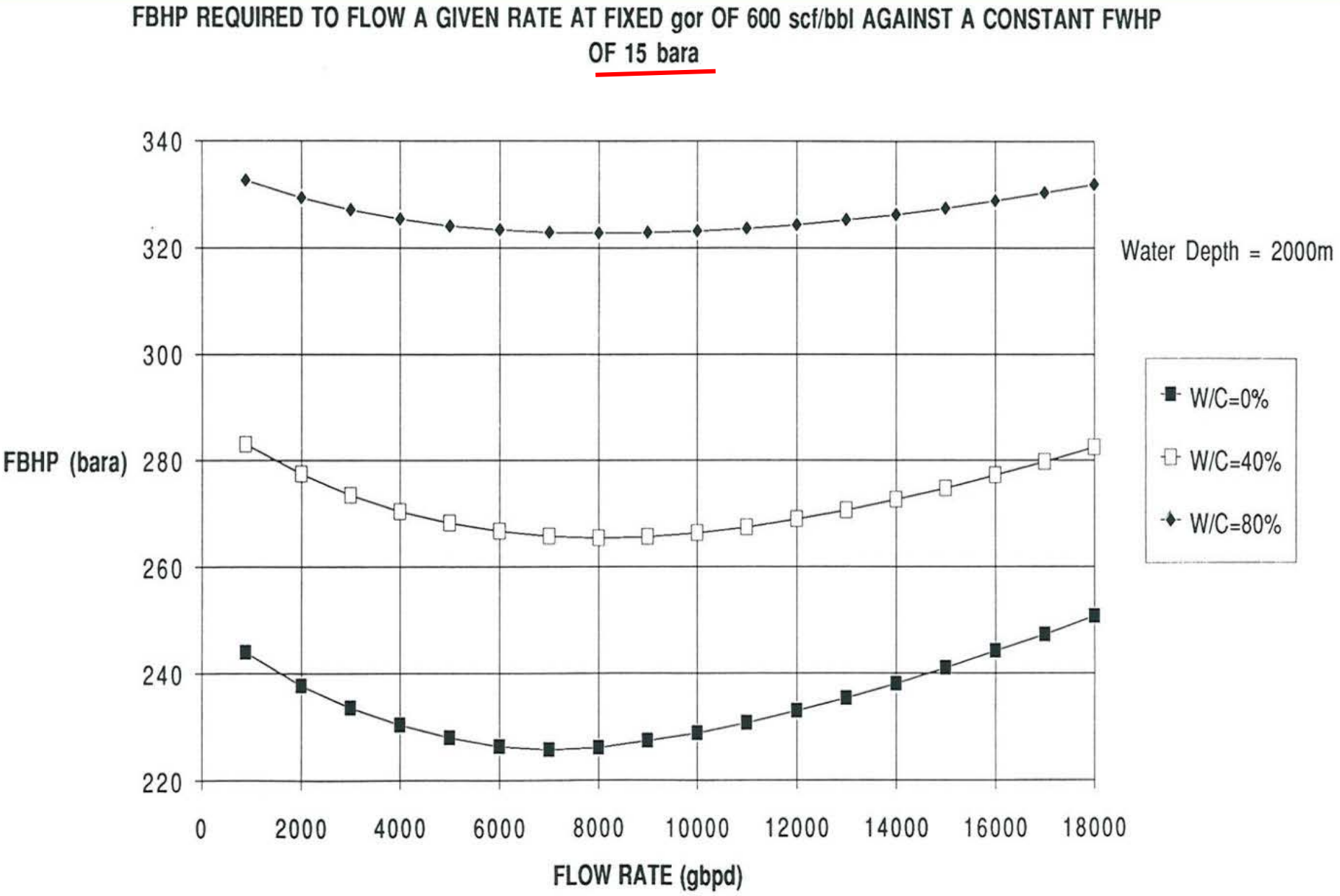
- **2.5 Bscf of otherwise lost reserves recovered.**







WATER DEPTH 2,000m


FBHP REQUIRED TO FLOW A GIVEN RATE AT FIXED gor OF 600 scf/bbl AGAINST A CONSTANT FWHP OF 15 bara
FBHP (bara)
340
320
300
280
260
240
220
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
FLOW RATE (gbpd)
Water Depth = 2000m
W/C=0%
W/C=40%
W/C=80%

TYPICAL PRESSURE LOSS ALONG PIPELINES

Flowline Sizing Analysis - Multi-Well Tie-Back

Water Depth Option	2000m			3000m		
Flowline Nominal Size (Inches)	18	20	22	18	20	22
Flowing Wellhead Pressure (bara)	228.2	228.2	228.2	328.0	328.0	328.0
Pressure at Host Facilities (bara)	20.7	38	47.9	33.4	51.4	61.1
Total System Pressure Drop (bar)	329.3	312.0	302.1	416.6	398.6	388.9
PI-Severe Slugging Group at Riser Base	0.11	0.12	0.17	0.13	0.17	0.25
Flowline Pressure Drop						
Frictional (bar)	55.9	30.8	18.4	52.7	29.6	18.1
Static (bar)	151.6	159.4	161.9	241.9	247.0	248.8
Total (bar)	207.5	190.2	180.3	294.6	276.6	266.9

Notes:

1. gor = 600 scf/bbl
2. watercut = 40%
3. flow = 100,000 gbpd
4. Reservoir Static Pressure: 2000 m = 350 bara; 3000 m = 450 bara
5. Flowline Length = 100 km

TABLE 6.6.4 - B
NATURAL FLOW HYDRAULIC ANALYSIS
MULTI-WELL TIE-BACK - 3000m WATER DEPTH OPTION

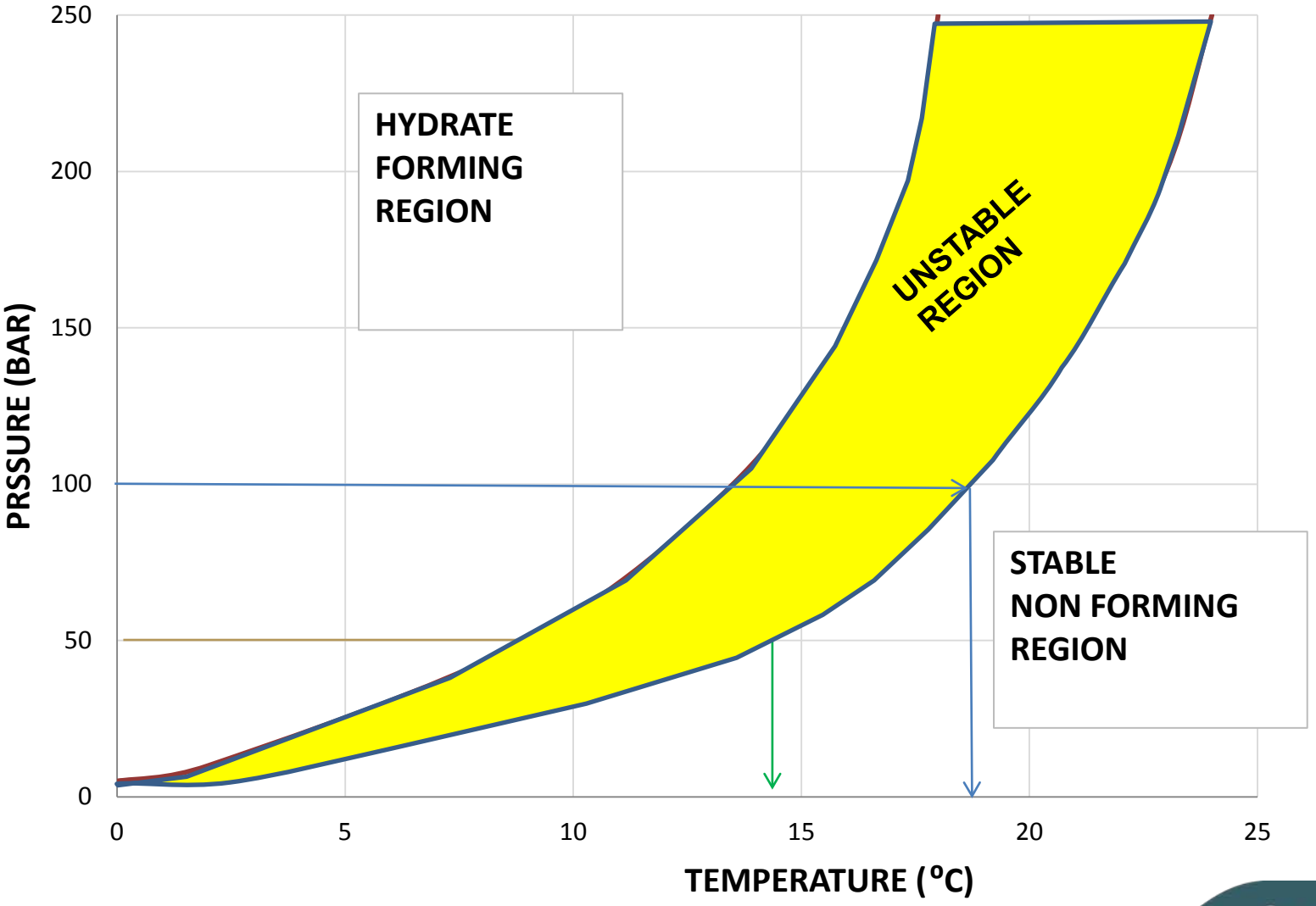
Case	gor=200 scf/bbl			gor=600 scf/bbl			gor=1000 scf/bbl		
Watercut (%)	0	40	80	0	40	80	0	40	80
Flowing Bottom Hole Pressure (bara)	417.6	453 *	490.9 *	391.4	426.3	477.7 *	382.8	410.9	465.5 *
Flowing Wellhead Pressure (bara)	300.4	323.3	347.1	283.7	304.3	337.5	282.9	296.1	329.1
Pressure at Host Facilities (bara)	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Total System Pressure Drop (bar)	402.6	438.0	475.9	376.4	411.3	462.7	367.8	395.9	450.5
PI-Severe Slugging Group at Riser Base	0.11	0.11	0.15	0.16	0.11	0.06	0.23	0.15	0.07
Flowline Pressure Drop									
Frictional (bar)	48.4	47.4	44.1	65.7	57.4	49.5	83.9	68.5	54.1
Static (bar)	237.0	260.9	288.0	203.0	231.9	273.0	184.0	212.6	260.0
Total (bar)	285.4	308.3	332.1	268.7	289.3	322.5	267.9	281.1	314.1

Notes:

1. 18" NB Flowline
2. Flowline Length = 100 km
3. flow = 100,000 gbpd
4. *Resrvoir Static Pressure = 450 bara

HIGH PRESSURE DROP DEMANDS SS BOOSTING SYSTEMS TO IMPROVE PRODUCTION &RECOVERY

TYPICAL HYDRATE FORMATION CURVE



IF YOU CANT MEASURE, YOU CANT CURE OR IMPROVE

- THE NEED FOR DATA COLLECTION, DOWNHOLE,INDIVIDUAL WELLS, SUBSEA LINE AND SUBSEA EQUIPMENT
- RELIABLE INSTRUMENTS ARE NEEDED
- RELIABLE DATA TRANSMISSION IS NEEDED
- RELIABLE AND EFFICIENT DATA MANAGEMENT SYSTEM IS NEEDED

SUBSEA METERING/WELL TESTING

- KNOWLEDGE OF PRODUCTION RATE OF G/W/OIL IS IMPORTANT FOR MANAGEMENT OF PRODUCTION
- METERING PRODUCTION FROM SATELLITE WELLS IS ALSO NEEDED
- NO RELIABLE SS MULTIPHASE METERING SYSTEM EXISTS, BUT SOME HAVE BEEN USED
- FOR TESTING SS WELLS A TEST MANIFOLD + METRING SYSTEM IS NEEDED
- ACCURACY OF METRING MAY HAVE TO BE COMPROMISED FOR THE TIME BEING

CHEMICAL INJECTION

A variety of chemicals are introduced at wellhead to achieve flow assurance, including;

- **HYDRATE INHIBITOR**
- **CORROSION INHIBITOR**
- **DRAG REDUCING AGENT**

There are also chemicals injected downhole;

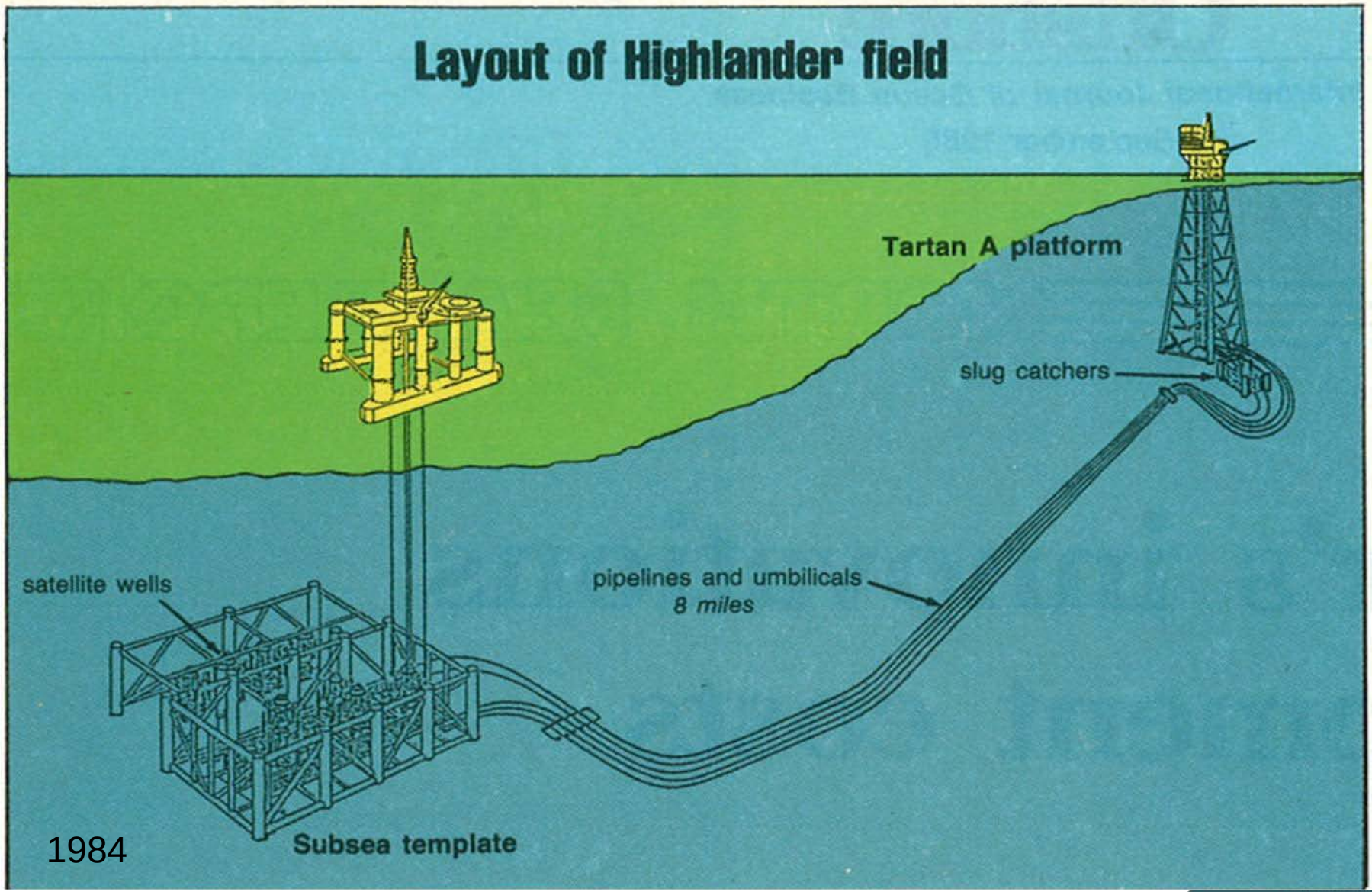
- **CORROSION INHIBITOR/SCALE INHIBITOR**
- **WATER TO REDUCE SALINTY OF PRODUCED WATER**
- **FOAMING AGENT/OTHER COCKTAILS&SOLVENTS**

PIGGING REQUIREMENTS

- MOST PIPELINES REQUIRE PIGGING TO CLEAN THE LINE OR TO INSPECT THE LINE INTERNALLY
- SS PIG LAUNCHER AND RECEIVER ARE NEEDED
- THERE IS A REASONABLE TRACK RECORD
- INCREASE IN OPEX & CAPEX IF ALL PIGGING SYSTEM IS SUBSEA ;
- THERE IS EXPERIENCE IN SS PIGGING

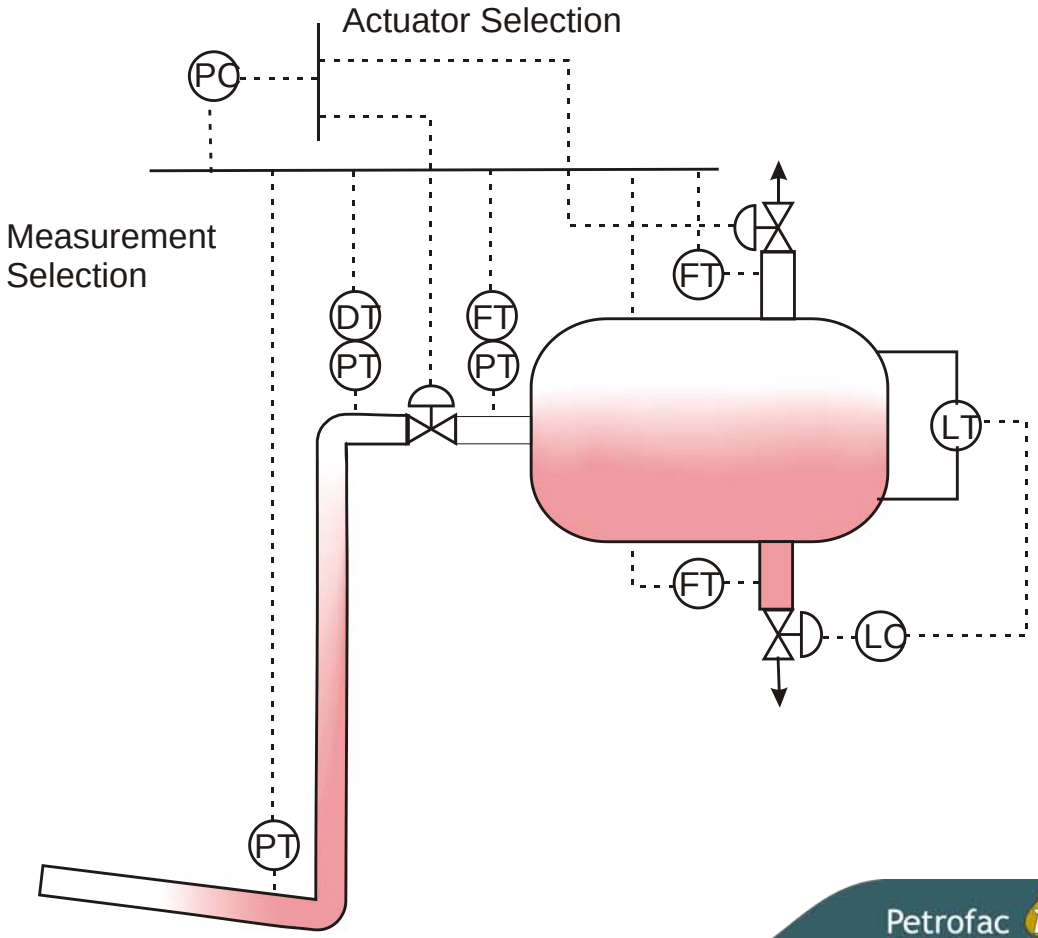
RISER GENERATED PROBLEMS

- SLUG GENERATION –EFFECT OF RISER PROFILE
- PRESSURE LOSS/ FLOW SURGE/SLUGGING
- GAS LIFTING AT BASE OF RISER
- SLUG CATCHER AT THE BASE OF RISER
- RISER STRUCTURAL INTEGRITY-SLUG EFFECT
- NEW TECHNIQUE TO MINIMISE RISER GENERATED SLUGGING

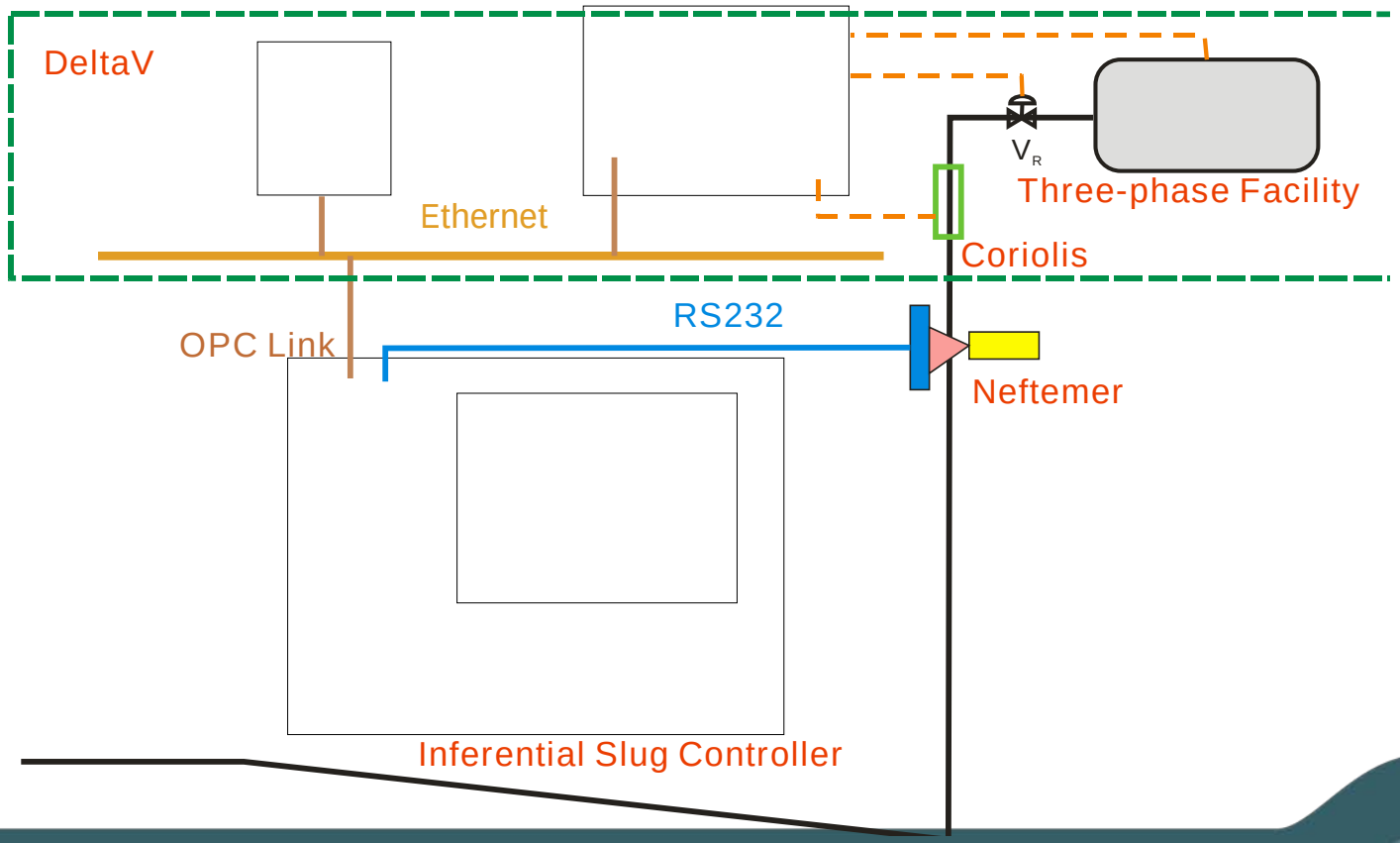

Layout of Highlander field
Tartan A platform
slug catchers
satellite wells
pipelines and umbilicals
8 miles
Subsea template
1984

General Slug Control Structure Cranfield university

- **Measurement candidates:**
  - **Different pressures**
  - **Different flow rates**
  - **Density**
  - **Levels**
- **Alternative actuators**
  - **Riser outlet choke**
  - **Gas outlet choke**
  - **Gas injection**

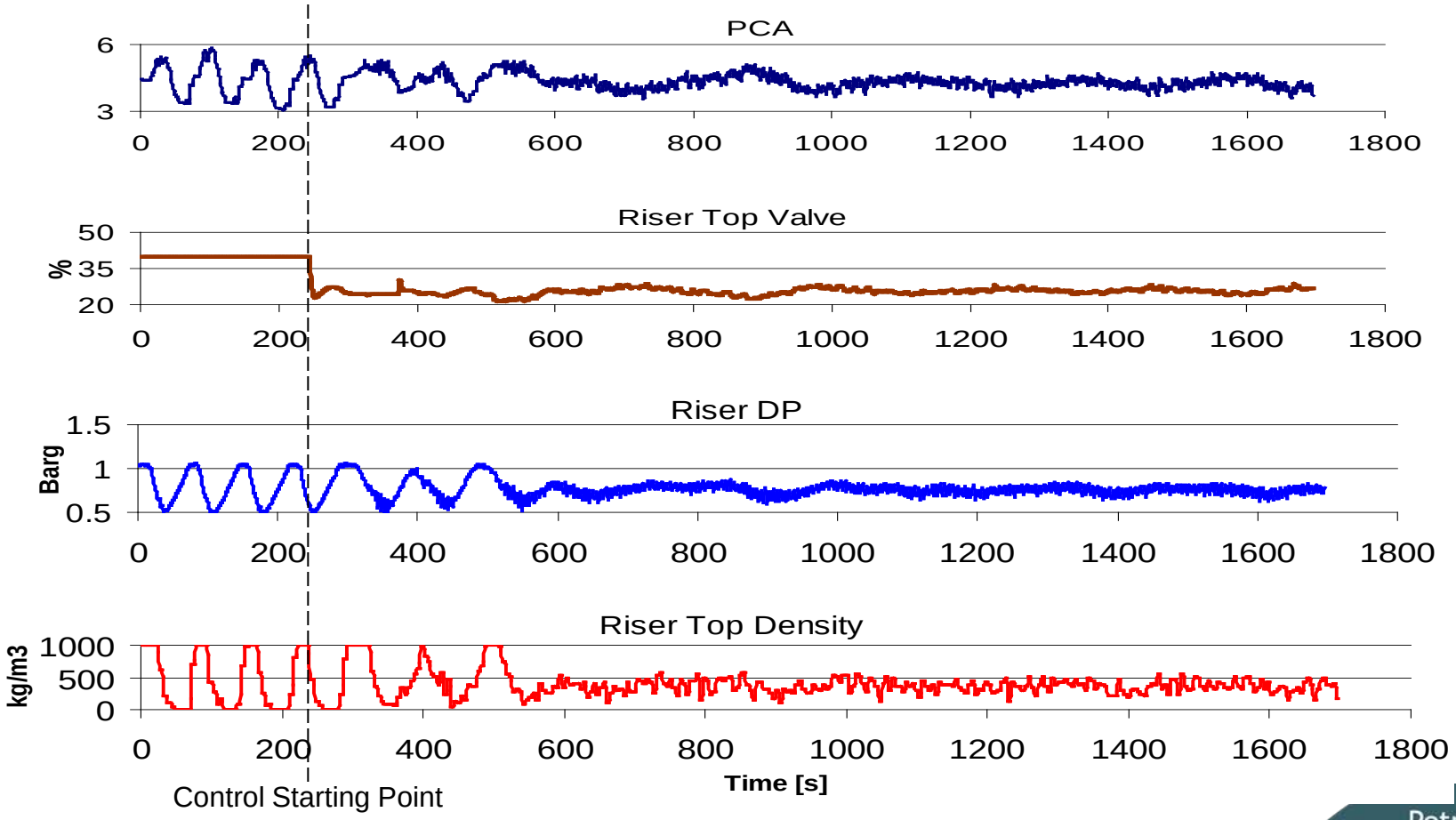


Inferential Slug Control (ISC) on Cranfield Facility

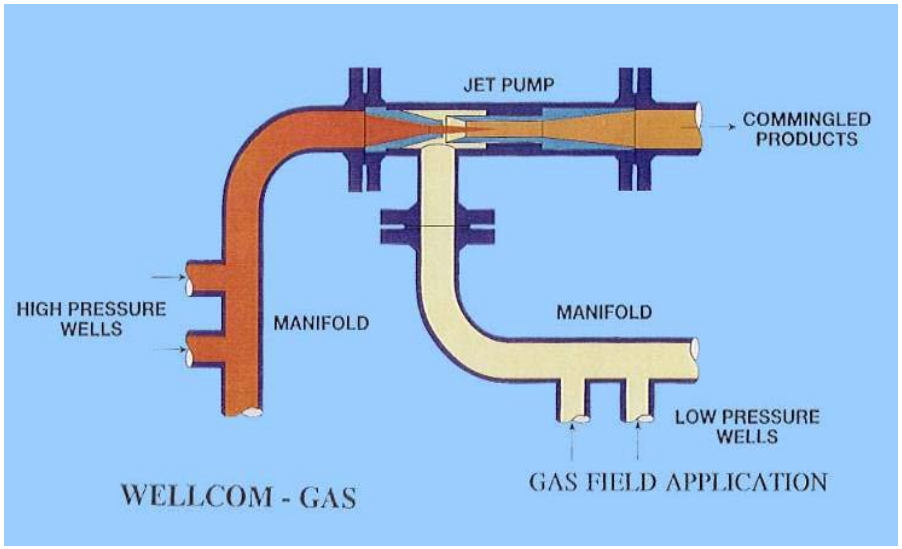


ISC Experimental Results

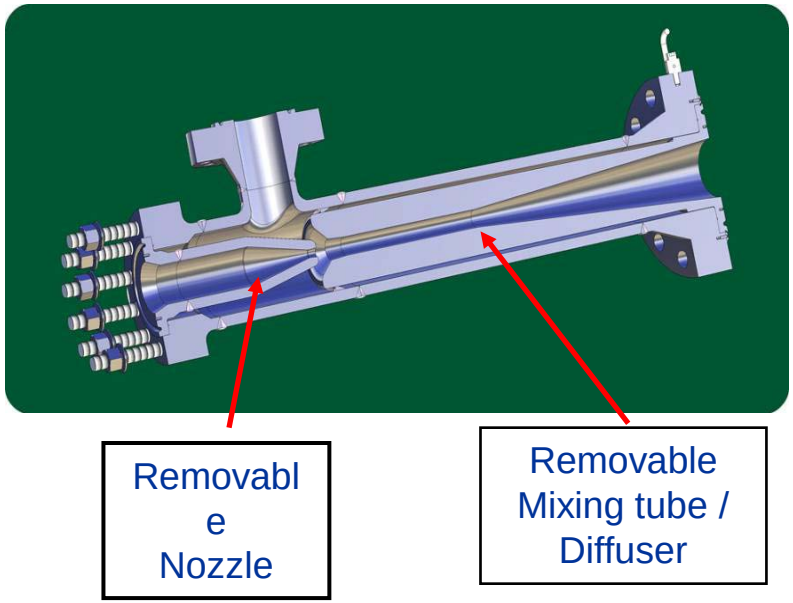
- Qa=20 Sm3/r, Qw=2kg/s;
  Top Valve stabilized around 26% of opening



JET PUMP TECHNOLOGY



Patented Universal Design Jet Pump

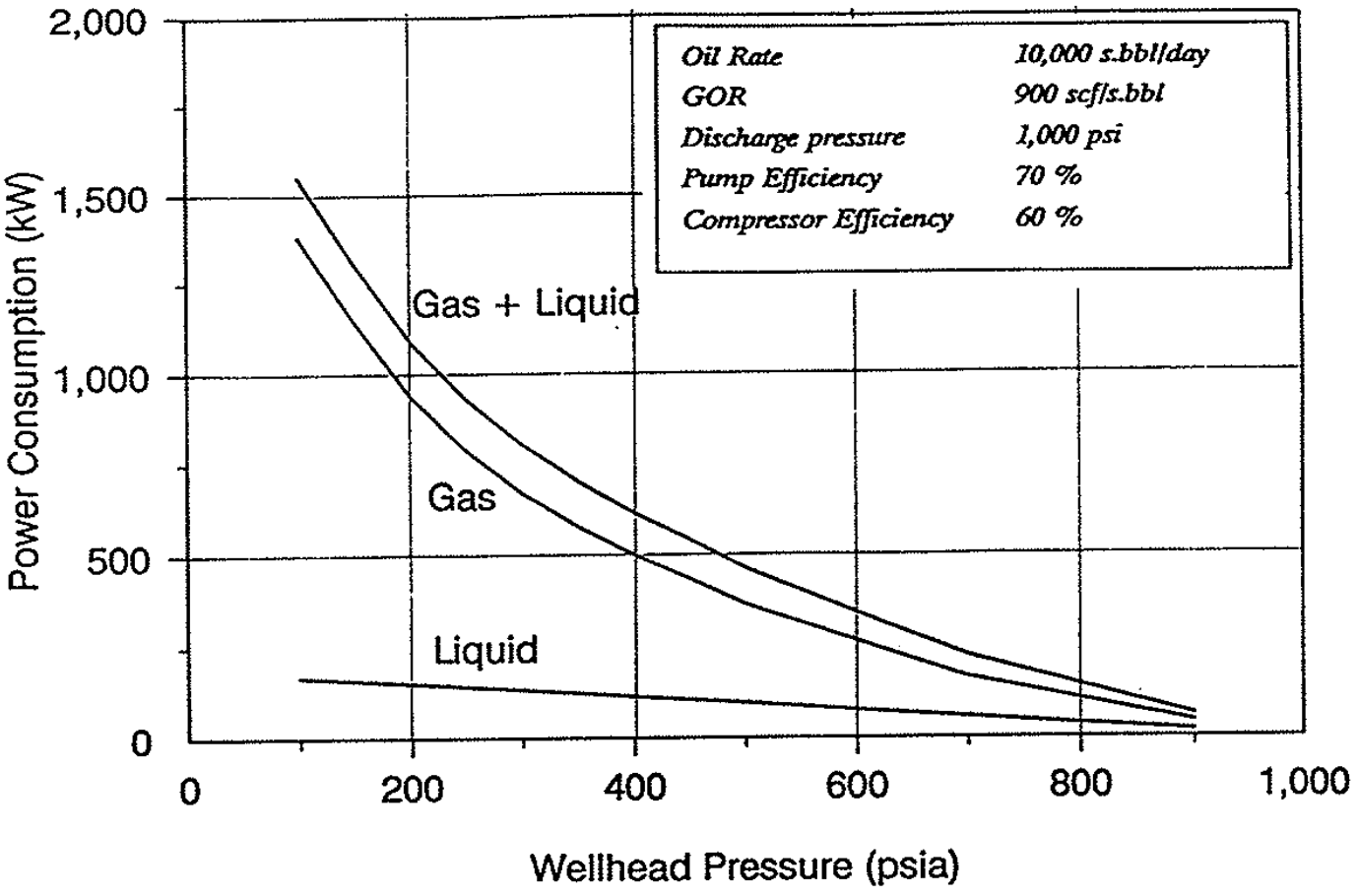


- JET PUMPS HAVE POTENTIAL APPLICATIONS FOR SUBSEA
- BEING A PASSIVE DEVICE WITH NO MOVING PARTS ,ARE IDEAL FOR SS
- TO COPE WITH CHANGING FIELD CONDITIONS ,TWO OR THREE UNITS CAN BE INSTALLED
- THEY CAN ALSO BE EASILY RETRIEVED AS A MODULE
- THEIR MAIN USE SO FAR HAS BEEN DOWNHOLE

SS MULTIPHASE PUMPS

- BASICALLY TWO TYPES;HELICO AXIAL,TWIN SCREW- MAINLY TWO PLAYERS
- HIGH POWER CONSUMPTION- 1 TO 3.5 MW
- CAN TOLERATE UP TO 100% GAS FOR A SHORT PERIOD
- VARIABLE SPEED DRIVE IS NEEDED
- CLAIM MTBF OF 4 TO 8 YEARS!
- TRACK RECORD; 5-10 YEARS,BUT ONLY A FEW UNITS HAVE BEEN INSTALLED

COMPARISON OF POWER REQUIREMENTS FOR MPP VS SPP



Effect of Wellhead Pressure on Pumping and Compression Power.

PROS AND CONS OF SS MULTIPHASE PUMPING

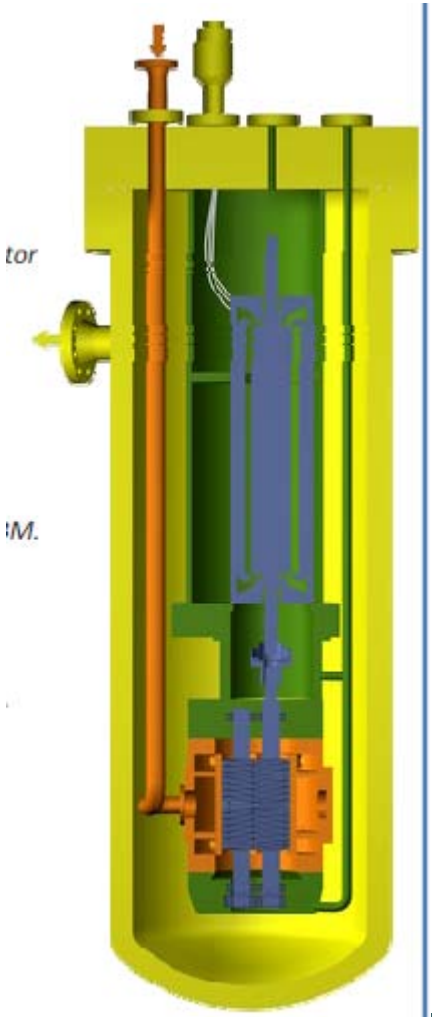
PROS;

- **No separation of gas/liquids is needed**

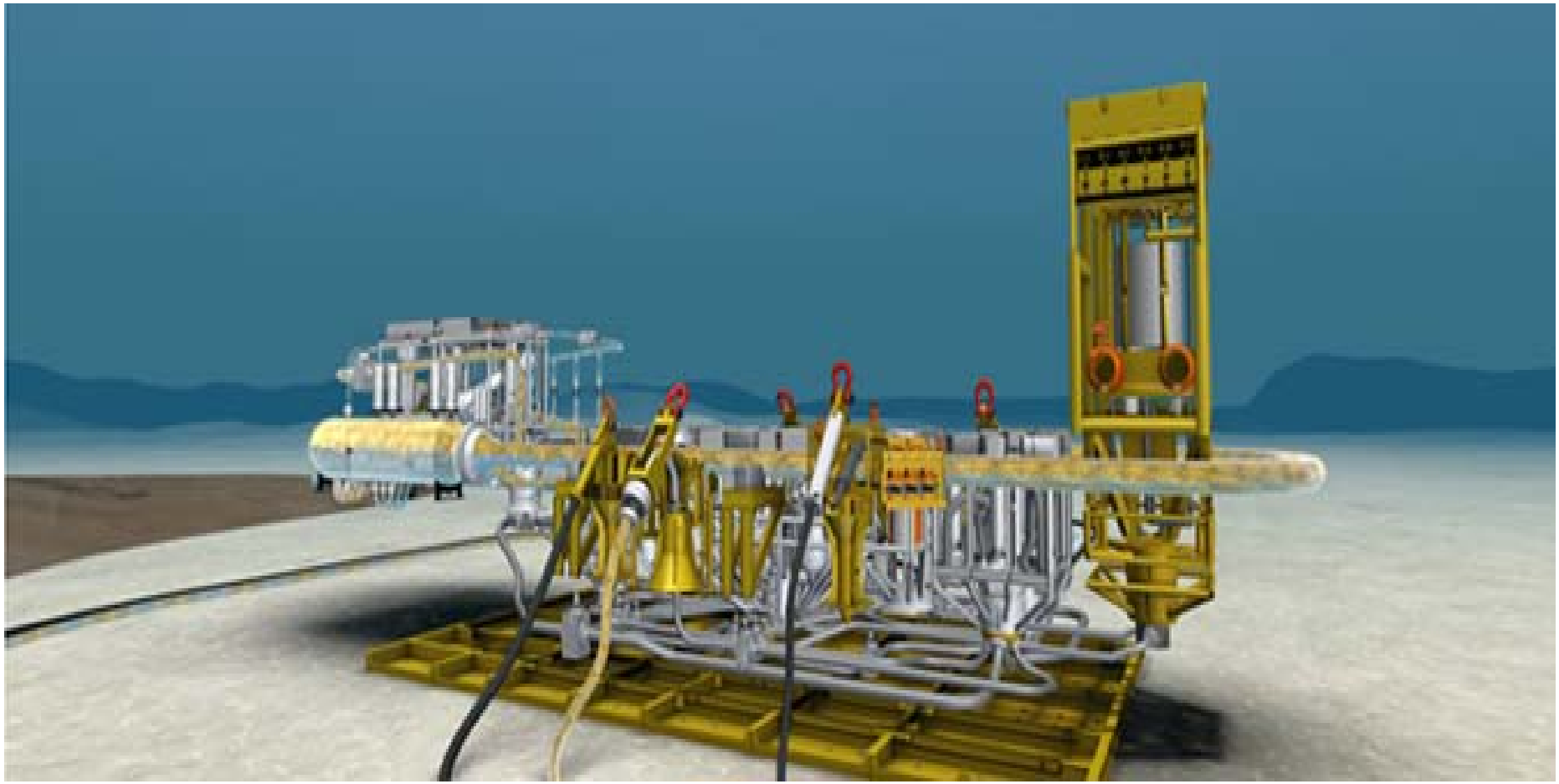
DISADVANTAGES;

- **Complexity of the system**
- **High power requirement (200 KW to 3MW)**
- **Complexities of high power supply**
- **Challenges of variable speed drive**
- **Heavy weight (100 to 200 tonnes)**
- **Limited track record/MTBF?**

BORNEMANN SS MPHP



SUBSEA MULTIPHASE PUMPING MODULE



OPERATORS SUBSEA TRACK RECORD

STATOIL

- SS PROCESSSING STARTED 1997,LUFENG FIELD
- 500 SUBSEA WELLS
- TARGET FOR STANDARD SS FACTORY BY 2020

PETROBRAS

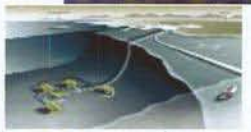
- FIRST SS SYSTEM 1979
- 800 SS WELLS
- 16 SS ESPS
- FULL SS SEPARATION+ SS WATER INJECTION

Longer, Deeper, Colder

Technology an enabler for growth

2009 Tyrihans

2007 Ormen Lange/Snøhvit



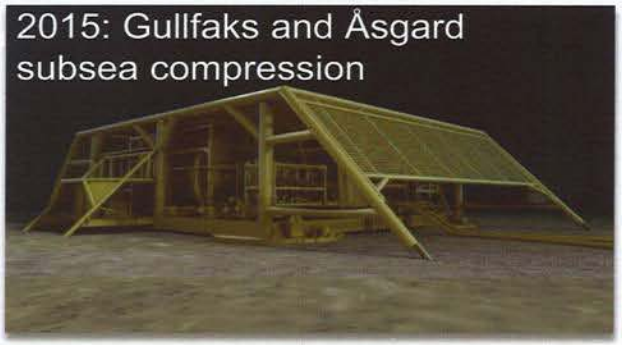
2007 Tordis

2005 Kristin

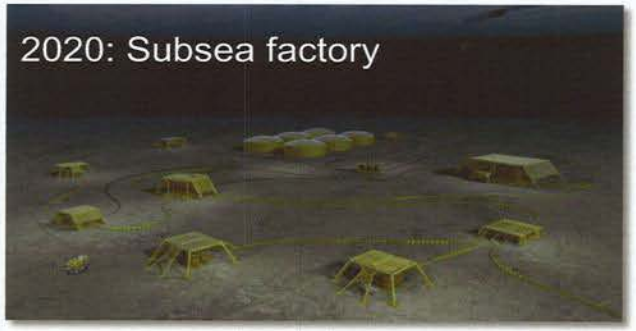
1999 Åsgard

1986 Gullfaks

2015: Gullfaks and Åsgard subsea compression



2020: Subsea factory



Subsea production

Experience Roadmap - Facilities

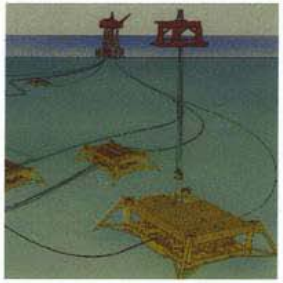
1st generation

Gullfaks, Tommeliten

1986-1990

2nd generation

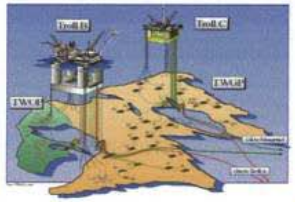
Sleipner sat, Statfjord sat, Heidrun, Norne



1991-1995

3rd generation

Yme, Lufeng, Åsgard, Gullfaks sat2, Sygna, Sigyn, Troll

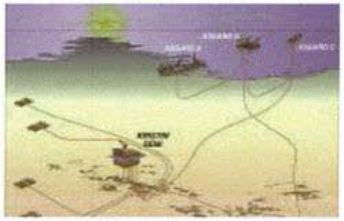


1996-2000

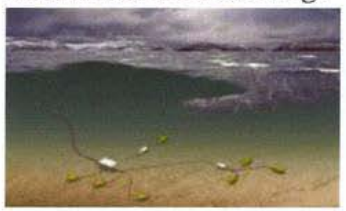
Simplification and cost-reduction
Enabling floating production systems

4th generation

Kristin, Morvin, Tordis SSBI



Snøhvit & Ormen Lange*

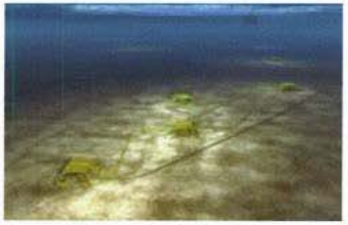


2004-2007

New technical challenges
HTHP, subsea to shore

5th generation

Tyrihans



Vega, Gjøa*

2007-2015+

Robustness & IOR focus
Standard catalogue

CALTEC

Subsea processing

Experience Roadmap - Facilities

1986
Start multiphase pump development (Poseidon)

1996
Gullfaks
Topside multiphase pump

1997
Lufeng
Subsea single phase pump

1994
Draugen
Hydraulic multiphase pump

2000
Troll pilot
Subsea water removal and injection

1996
Elsmubs
JIP: Electrical subsea pump

2003
Norne tech. program
Subsea separtion concept dev.

2005
Troll Pipe sep.
Subsea water removal, qualific.

2003
WGC
Demo 2000: Wet gas compressor

2006
Ormen Lange
Statoil/Shell: Subsea compressor TQP

2007
Tordis
Subsea water removal, injection, multiphase boosting

2010
Jack St Malo
Chevron: Deep water pump qualification

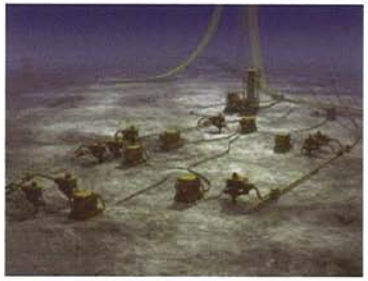
2008
Åsgard TQP
Subsea compress testing at K-lab

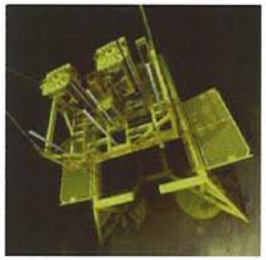
2011
Pazflor
Total: separation and liquid boosting

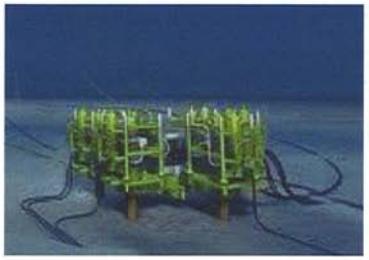
2009
Tyrihans
Raw sewater injection. RFO.

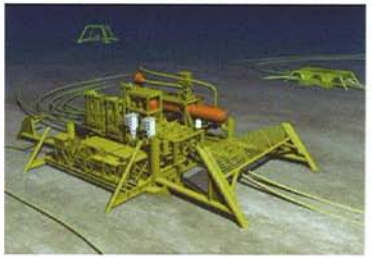
Statoil operated

Partner operated / JIP









TOTAL-PAZFLOR WEST AFRICA
SS SEPARATION AND BOOSTING

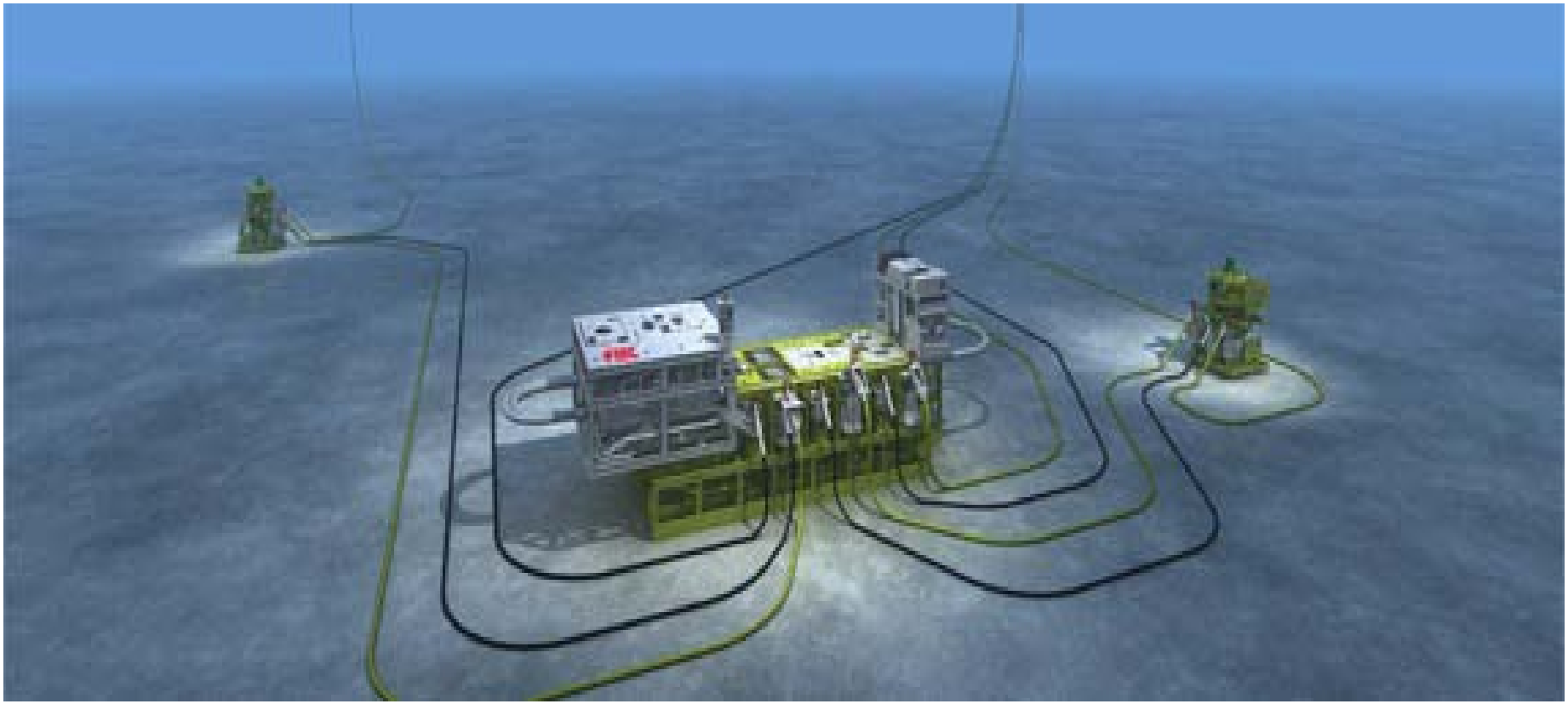
PETROBRAS TRACK RECORD

- FIRST SS TREE 1979
- 800 SS WELLS
- 16 DOWNHOLE SS ESPS
- 16 MUDLINE ESPS
- 1 HELICOAXIAL MPP
- 3 SS RAW WATER INJECTION
- 1 SS SEPARATOR
- 1 SS OIL-WATER SEP

CHALLENGES;

- ASSETS DONT FUND DEVELOPMENT WORK
- INTERFACES ARE TOO COMPLEX
- TOO MUCH TOPSIDE EQUIPMENT NEEDED
- TOO COSTLY SYSTEMS

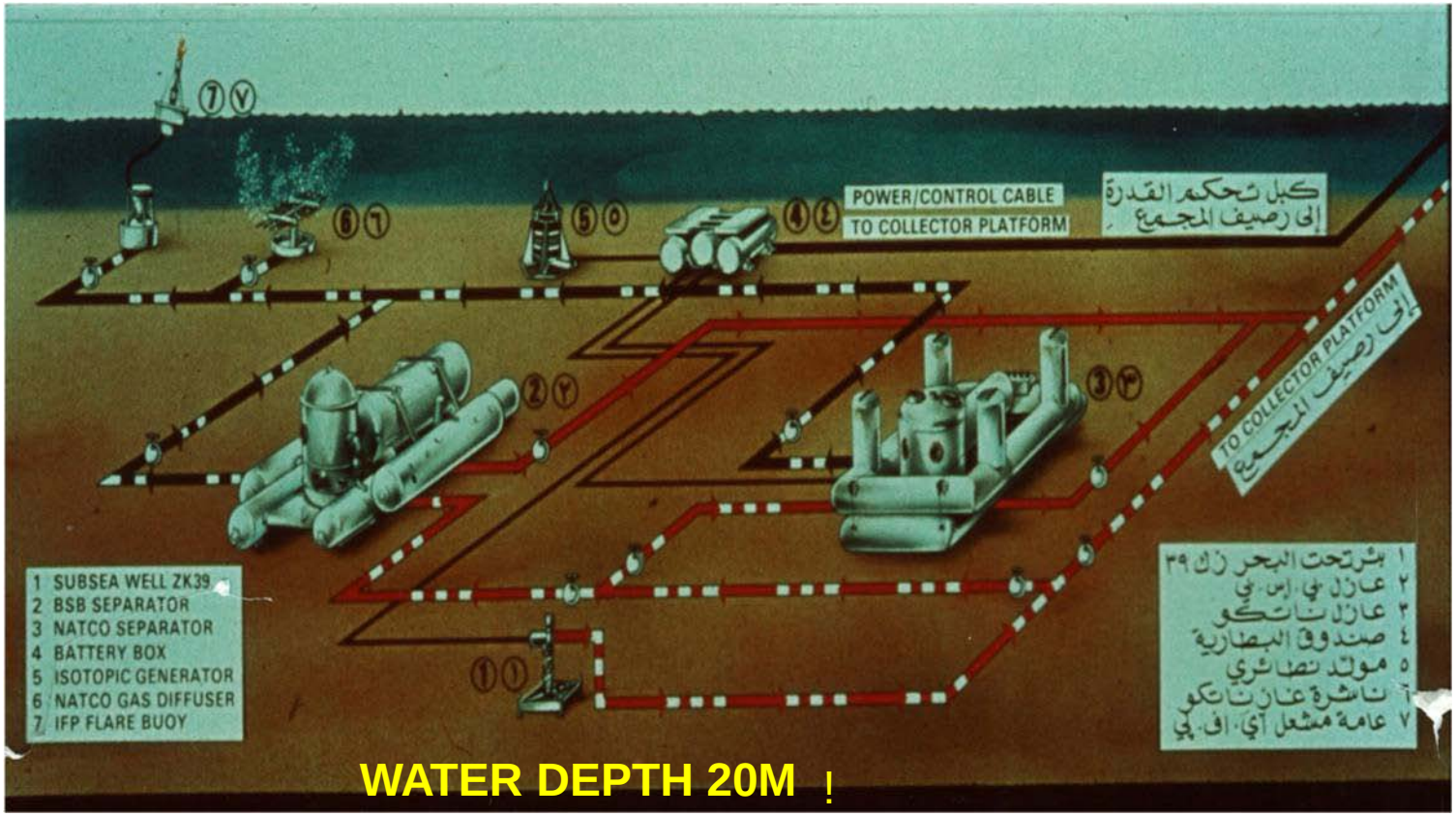
MARLIM SUBSEA SYSTEM ,Brazil-OIL-WATER SEP,SS OIL PUMP,SS WATER INJECTION PUMP,SS CYCLONIC WATER TREATER- 100 PPM OIW



SUBSEA SEPARATION

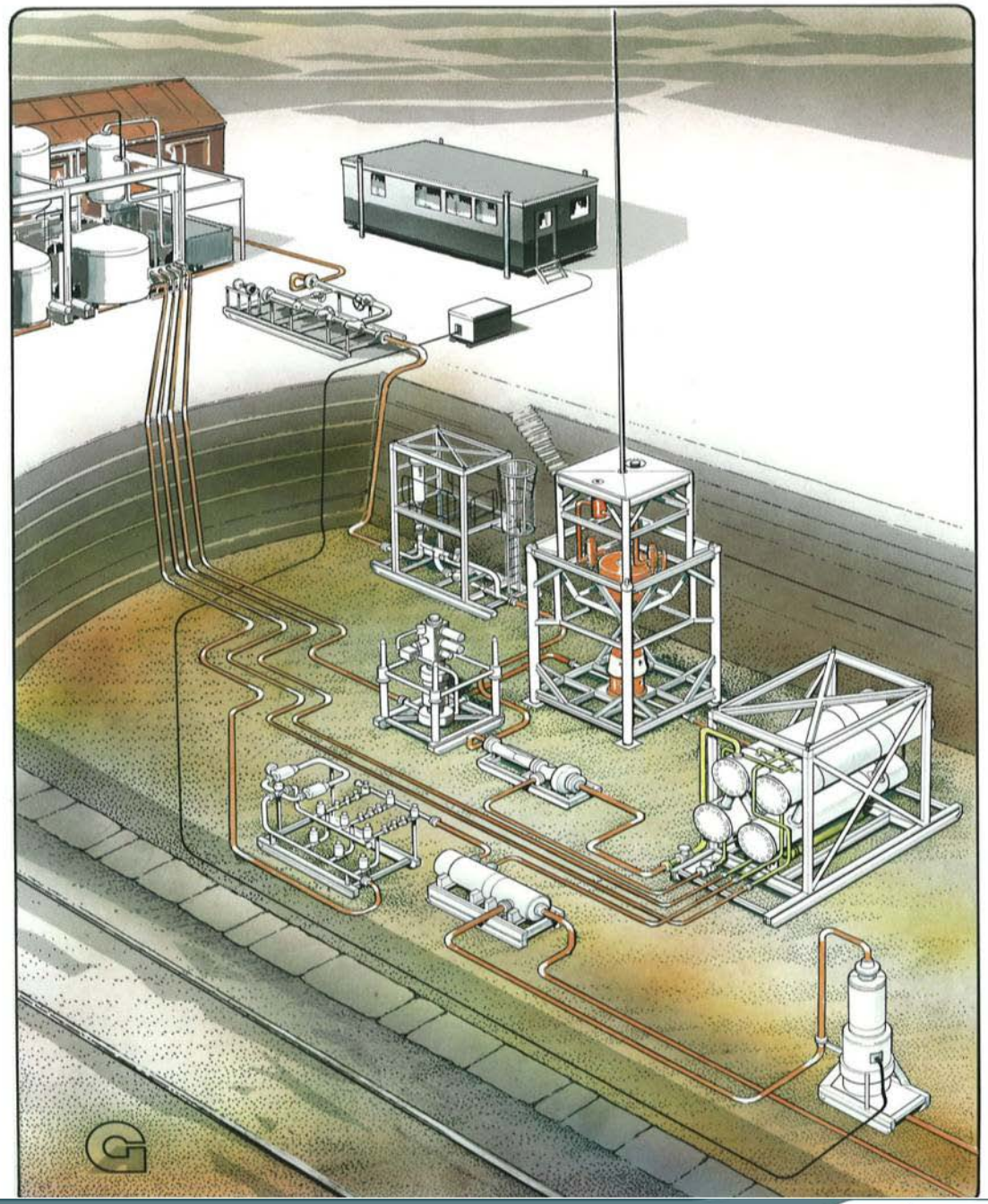
- G-L SEPARATION- GAS TRANSPORTED UNAIDED,LIQUIDS BOOSTER FOR LIQUIDS
- OIL-WATER SEPARATION-INJECT WATER TO RESERVOIR
- G-L SEPARATION- SS COMPRESSION + SS LIQUIDS PUMPING

FIRST SS SEPARATOR TRIALS
ZAKUM FIELD-BP-1969-72

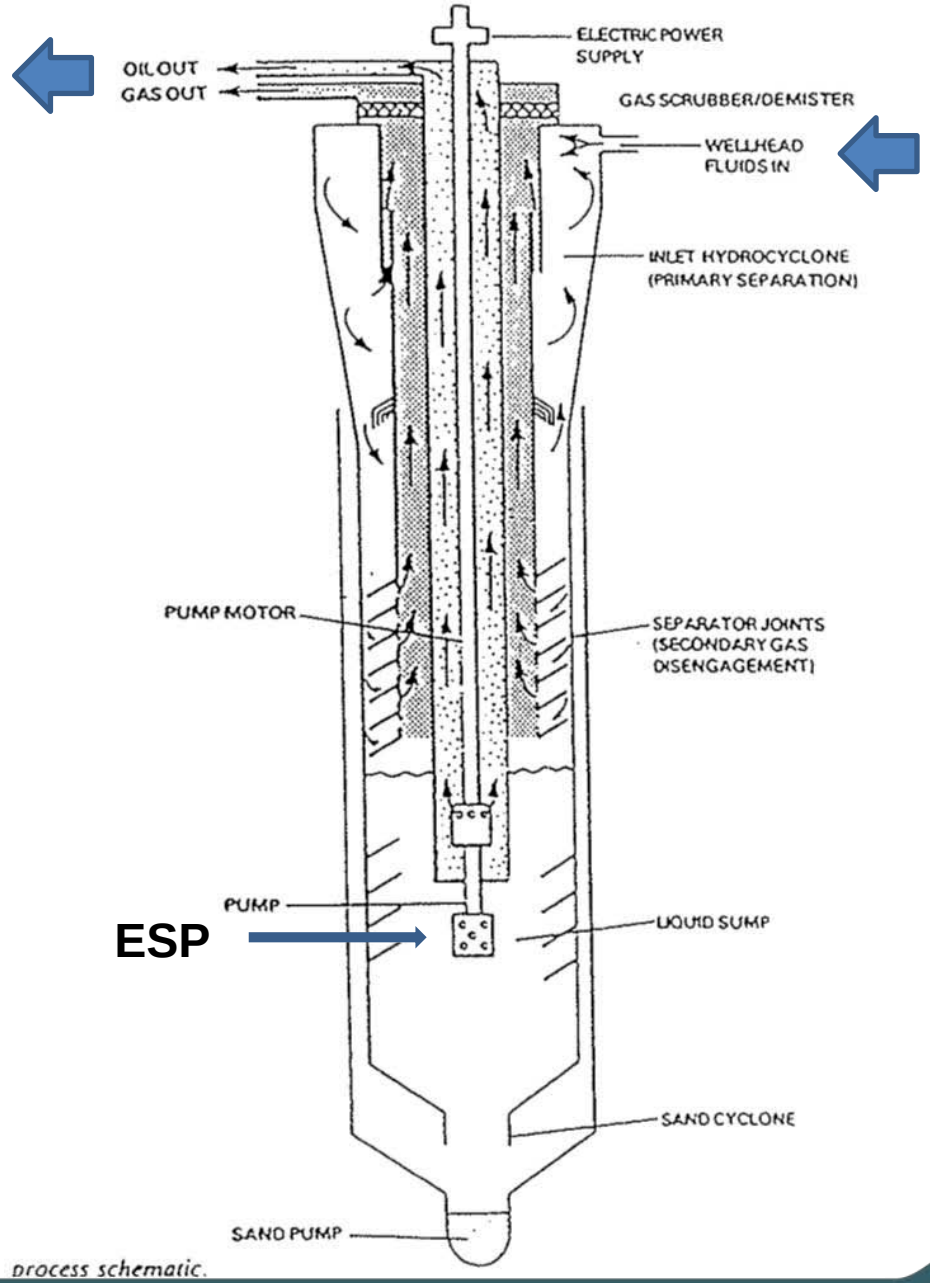


GASPS/GLASS
GA SUBSEA PRODUCTION SYSTEM

1990



VASP SEPARATOR



TORDIS SS SEPARATION SYSTEM

Separator Efficiency Tests at Arnhem

HI-SEP
I-SEP

CAL 6W02000R
CALTEC
Production Solutions
I-SEP
CALTEC
Production Solutions

I-SEP
HI-SEP

TABLE 1—SUBSEA SEPARATION INSTALLATIONS

Operator/Year	Field	Technology Used	Technology Type	Technology Supplier	Water Depth (ft)
Statoil 2001	Troll C	Horizontal SUBSIS	Separator	GE/Fram	1,116
Petrobras 2001	Marimbá	VASPS	Separator & ESP	Saipem	1,265
Statoil 2007	Tordis	Horizontal	Separator	FMC/CDS Engineering BV	689
Shell 2009	BC-10	Caisson	Separator & ESP	FMC/CDS Engineering BV	6,562
Shell 2010	Perdido	Caisson	Separator & ESP	FMC/CDS Engineering BV	9,600
Petrobras 2011	Marlim	Inline	Separator	FMC	2,881
Total 2011	Pazflor	Vertical Separator	Separator	FMC/CDS Engineering BV	2,625
Petrobras 2012	Congro	VASPS	Separator & ESP	FMC	Not Available
Petrobras 2012	Malhado	VASPS	Separator & ESP	FMC	Not Available
Petrobras 2012	Corvina	VASPS	Separator & ESP	FMC	Not Available
Petrobras TBA	Canapu	Inline Supersonic	Separator	FMC/Twister BV	5,579

SUBSIS—Subsea separation and injection system
VASPS—Vertical annular separation and pumping system
ESP—Electrical submersible pump
Source: OTC 23622.

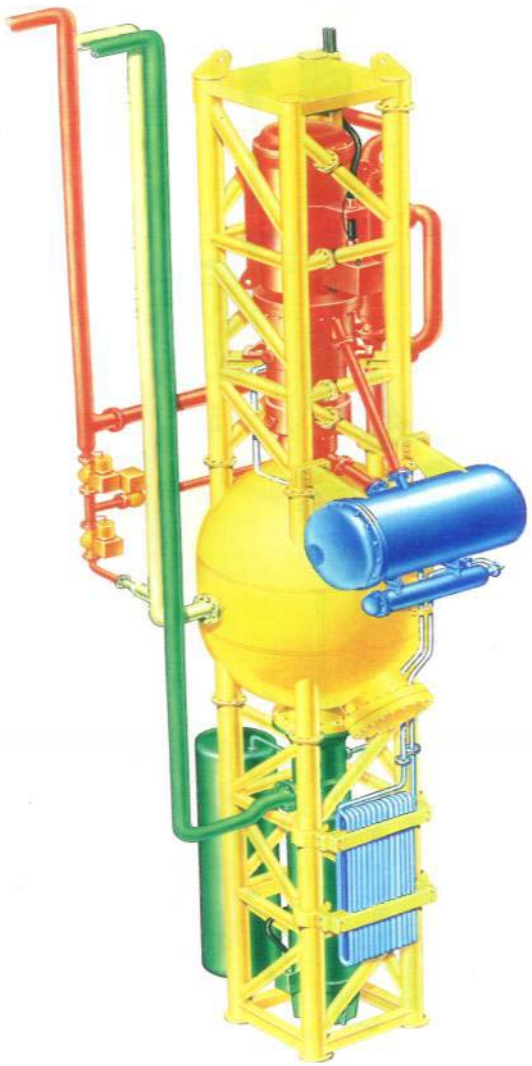
Caltec inline Oil/Water separator (WX), Debottlenecking three phase separators

Caltec Oil-Water Separator (3750 bpd)

Samples obtained:

1) Fluid from Final Polishing Unit
2) Caltec clean water outlet
3) Caltec oil outlet sample

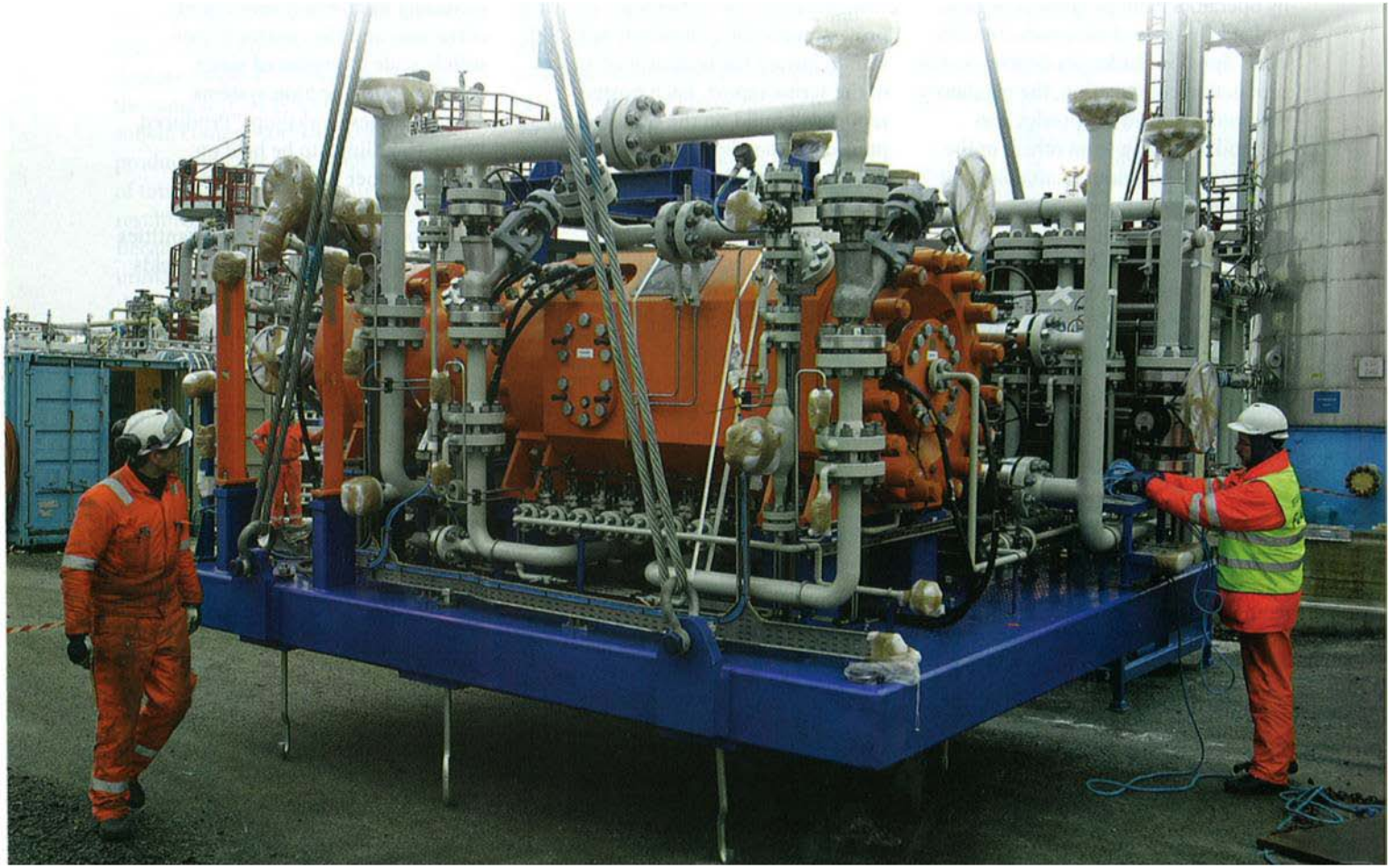
KAVERNER BOOSTER STATION
PROTOTYPE
G-L SEPARATOR
COMPRESSOR
DP;45 BAR
QL;10,000 B/D
QG;6-7 MMSCFD



SUBSEA COMPRESSION FOR ORMAN LANGE

12.5MW PILOT SS GAS COMPRESSION SYSTEM-
-860 m water depth, dp 60 bar

SUBSEA COMPRESSOR



CHALLENGES FOR SUBSEA EQUIPMENT

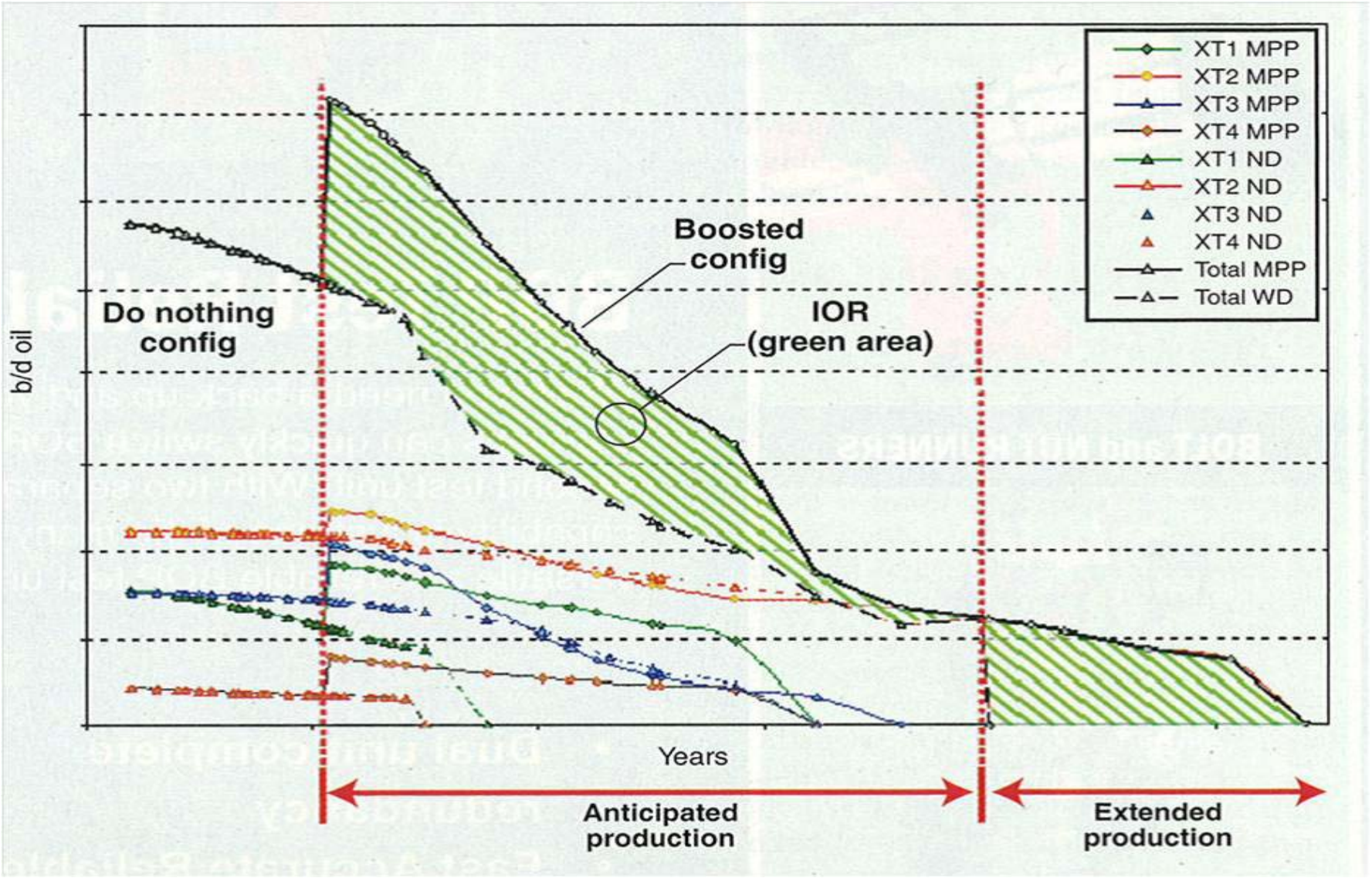
- RELIABILITY/MTBF- 5 to 8 years or longer
- RETRIEVABILITY/ surface vessel needed
- IMR REQUIREMENTS
- AVAILABILITY (REDUNDANCY)
- ENVIRONMENTAL ISSUES (LEAKS,RUPTURE..)
- TRACK RECORD
- IMPACT IF IT DOES NOT WORK
- COST
- ACCEPTANCE CRITERIA-APPROVALS

KEY ISSUES AFFECTING RELIABILITY

- RELIABILITY OF INDIVIDUAL COMPONENTS
- SYSTEM COMPLEXITY; NUMBER OF COMPONENTS AND THEIR FUNCTION/TYPE; MECHANICAL,ELECTRICAL,HYDRAULIC,SIGNAL,ETC
- TOTAL SYSTEM RELIABILITY
- REDUNDANCY
- RETRIEVABILITY/ACCESS
- COST OF RETRIEVAL/IMR (SERVICE VESSEL REQUIREMENTS)

HOW TO IMPROVE RELIABILITY AND MTBF

- IMPROVE INDIVIDUAL COMPONENTS
- ADD REDUNDANCY FOR SOME KEY COMPONENTS
- SHARE EXPERIENCE TO CORRECT OR UPGRADE WHAT HAS GONE WRONG BEFORE
- HAVE SUFFICIENT PROTOTYPE FULL SCAE TRIALS
- ASSESS FULL SYSTEM OPERATION &INTEGRITY, AS WELL AS KEY COMPONENTS
- SUPPORT DEVELOPMENT WORK TO IMPROVE COMPONENTS
- STANDARDISE KEY INTERFACE COMPONENTS

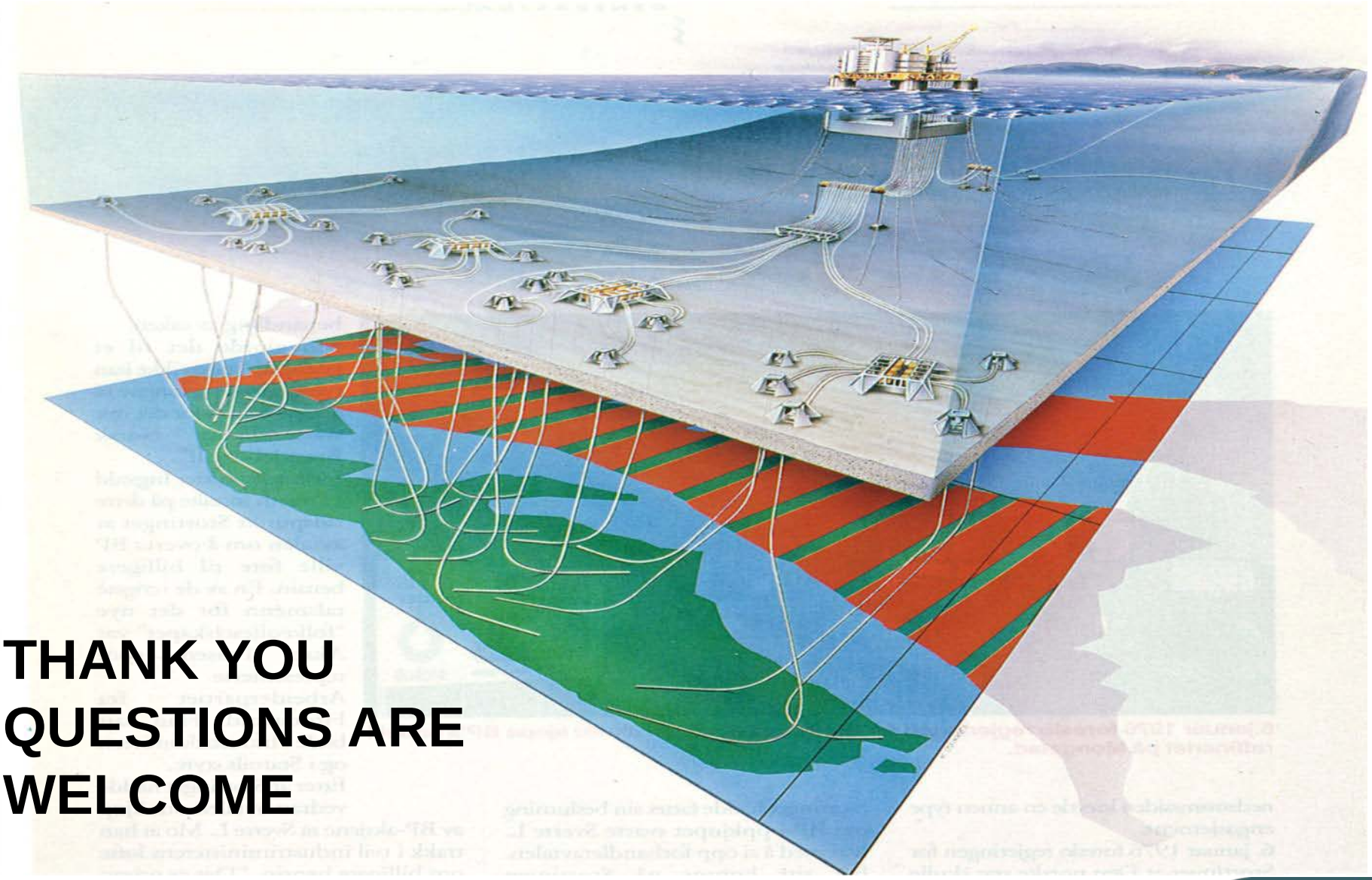

XT1 MPP
XT2 MPP
XT3 MPP
XT4 MPP
XT1 ND
XT2 ND
XT3 ND
XT4 ND
Total MPP
Total WD
Boosted config
Do nothing config
IOR (green area)
b/d oil
Years
Anticipated production
Extended production

CLOSING REMARKS

- SUBSEA PRODUCTION HAS PROGRESSED SLOWLY IN STEPS SINCE 1970s. IT IS NEEDED TO ACHIEVE HIGH RATE OF TOTAL RECOVERY FOR MANY FIELDS
- SS WELLS , MANIFOLDING AND MODULARISATION HAVE REACHED MATURITY, ROOM FOR IMPROVEMENT FOR COMPONENTS IN ALL AREAS
- SS SEPARATION HAS NOT PROGRESSED BEACAUSE OF LACK OF FULL SUPPORT-ROOM FOR IMPROVEMENT!
- MPHPs HAVE PROGRESSED, BUT NEED IMROVED MTBF,SS COMPRESSION IS IN ITS INFANCY

CLOSING REMARKS... CONTINUED

- HIGH INVESTMENT IS NEEDED TO DEVELOP & IMPROVE SS EQUIPMENT/SYSTEMS- WHO PAYS FOR IT?- OPERATOR,EQUIPMENT SUPPLIER?
- GLOBAL SS MARKET HAS RISEN FROM $18 BILLION IN 2003 TO $45 BILLION IN 2012
- EXTENSIVE FAT AND FULL SCALE SYSTEM TRIALS ARE NEEDED FOR THE SS SYSTEM
- COLLABORATION BETWEEN OPERATORS AND SUPPLIERS OF SS EQUIPMENT/SYSTEM IS NEEDED TO SHARE COSTS/RISKS/REWARDS
- STANDARDISATION/STANDARDS ARE NEEDED TO IMPROVE RELIABILITY/HSE AND SIMPLIFY QUALIFICATION/APPROVALS



THANK YOU
QUESTIONS ARE WELCOME