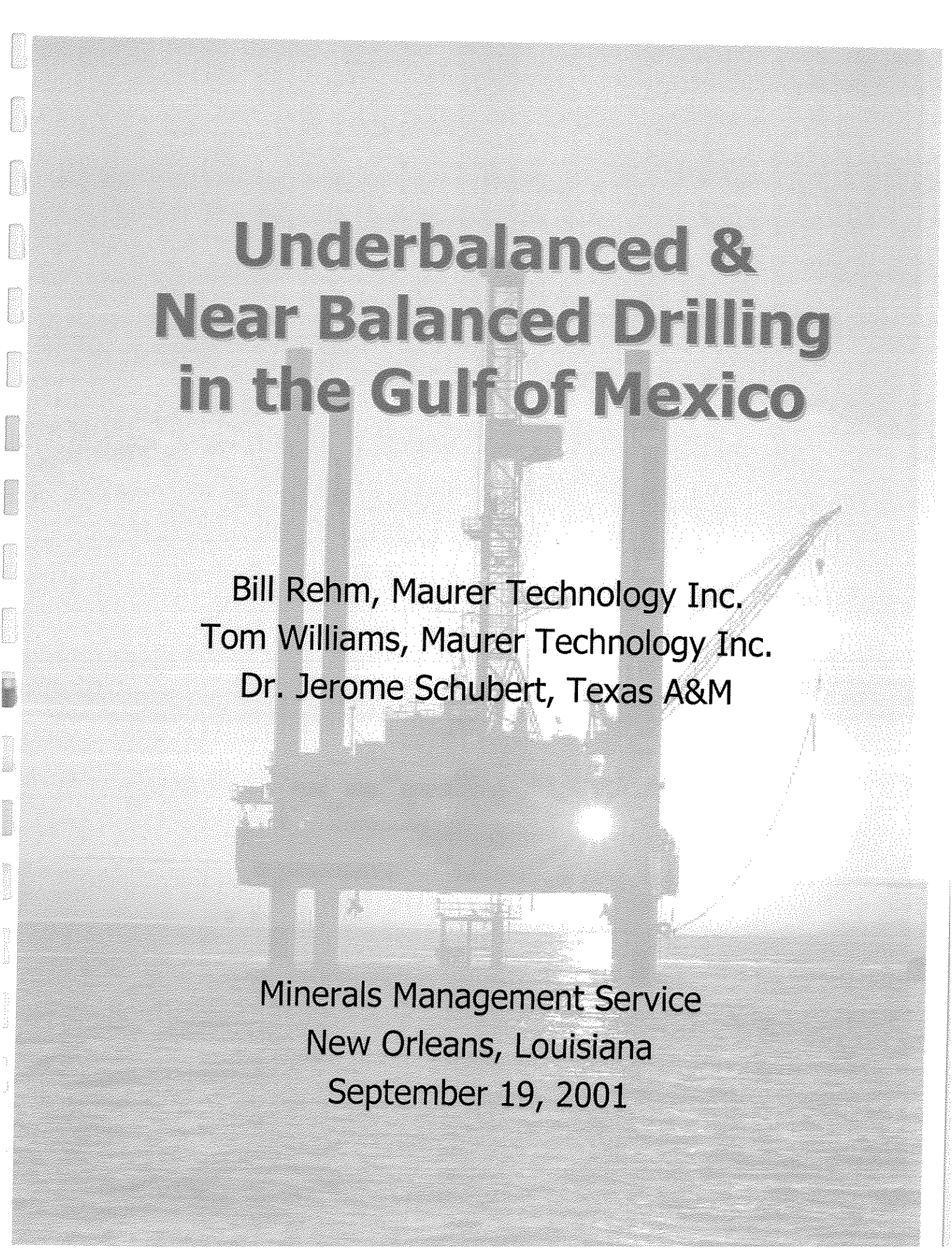
Underbalanced & Near Balanced Drilling in the Gulf of Mexico



Bill Rehm, Maurer Technology Inc.
Tom Williams, Maurer Technology Inc.
Dr. Jerome Schubert, Texas A&M

Minerals Management Service
New Orleans, Louisiana
September 19, 2001

Maurer Technology

Underbalanced & Near Balanced Drilling in the Gulf of Mexico

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MMS
New Orleans, La
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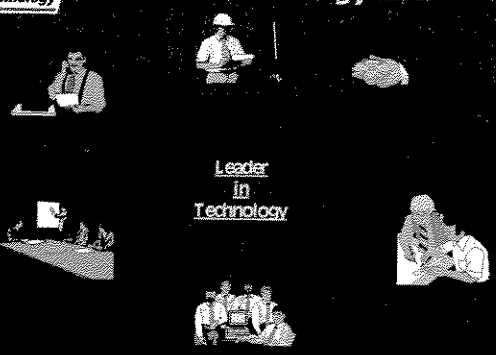
Maurer Technology

Maurer Technology Inc.



Leader
In
Technology

Maurer Technology

Maurer's Joint Industry Projects

Funded by:
Industry: Over 200 companies in 28 countries
Government: U.S. Department of Energy and the Minerals Management Service
Consortia: Drilling Engineering Association

Examples: Dual Gradient Drilling in Deep Water
DEA-42 Casing Wear Technology
DEA-44 Horizontal Well Technology
DEA-67 Coiled Tubing Technology
DEA-101 Underbalanced Drilling Technology

Goals: Transfer Advanced Technology
Develop
- New Technologies
- Engineering Software
- Advanced Tools and Equipment

AGENDA-MORNING

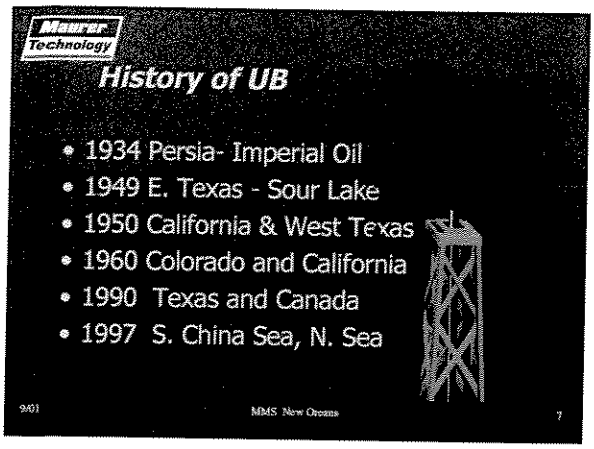
8:30 AM	Introductions: Marine UBD around the world Application Geological and Conditions that Control UBD Equipment
10:15 AM	Break
10:30 AM	Well Control (Discussion) Types of UB Systems Foam
12:00 PM	Lunch

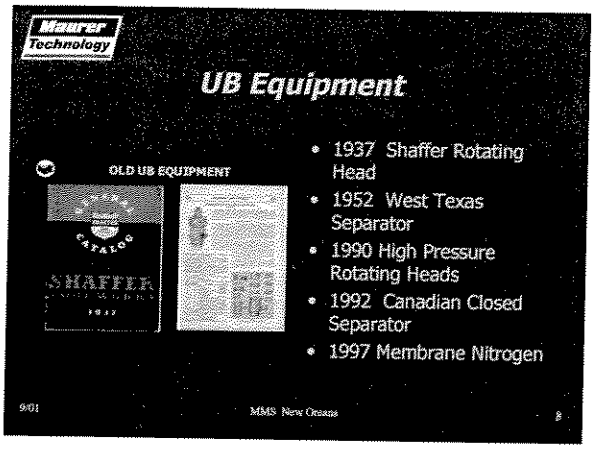
AGENDA-AFTERNOON

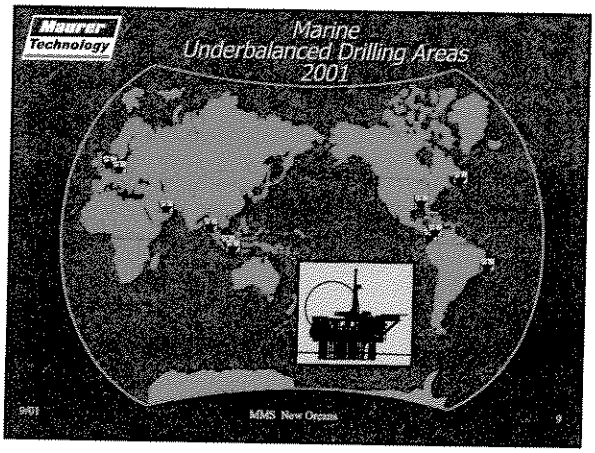
1:00 PM	Industry Goals (Discussion and Questions) Planning Tools Barriers
2:20 PM	Break
2:30 PM	Discussion Regulatory Concerns? References

Something About UB Drilling

- UB Drilling is a "new" tool that reduces costs due to lost circulation, differential sticking & reservoir damage.
- Well kick is a different definition. In UBD there is no "Well Kick", it may be part of the process.







Shell - N.S.

Norway - some UB in Northern fields

Oman - Persian Gulf

Canada - UBO in Lost circulation problem

Recorded Marine Incidents

- NONE
- WHY ?
  - Planning Care
  - Training
  - Inherent danger overstressed

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Brazil

- Petrobras
  N2-"Mud"
  Major project for UB drilling in deep water, one well drilled, 11 more in the project

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British North Sea

- Shell UK
  Brittania (Santa Fe)
  Ongoing project with more than 11 wells
- Other Projects

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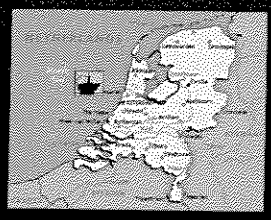
Shell put lots of people + procedures on project

Dutch North Sea



- NAM (Dutch Shell) (11 Wells)
- tight hole on information

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Indonesia

- MOBIL OIL
  Six wells
  SEDCO 601
  N^2/Water
- PERTAMINA
  Repsol-YPF-Maxus
  Krisna Field, N^2/Water
- Three wells completed-projected for 10 more

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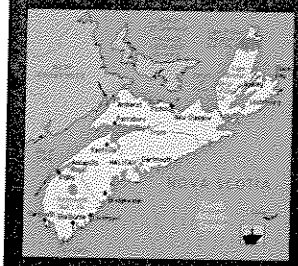
Nova Scotia



- Floating Mud Cap on surface holes because of lost circulation.
- 4 + wells, ongoing

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- Nova Scotia - use to get through lost circulation zone

Venezuela

- PDVSA
  SHELL-VEN.
  PHILLIPS
  CHEVRON
- 19+ wells or re-entries.
- Special tubing/drillpipe rigs for Schlumberger and Chevron

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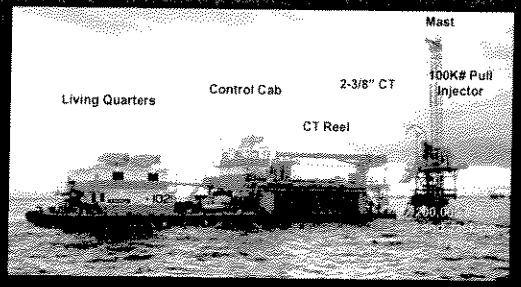
CTD Barge 1021 - Venezuela



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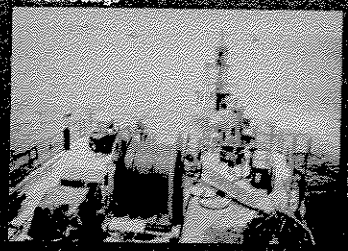
New Wells from Surface - Venezuela

- Lake Maracaibo
  - Shallow gas causes problems while drilling surface casings
  - Coiled Tubing drills 3 3/4" hole past the gas zones "remotely" from a barge



Present gas is easily diverted at surface

If no gas is found, rig will drill a normal well

Note : CT unit now casing the surface hole due to economics

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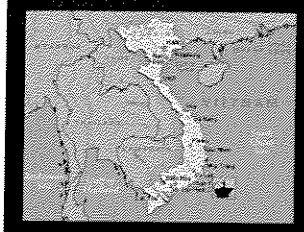
VIETAM



- Two wells

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Lost Circulation

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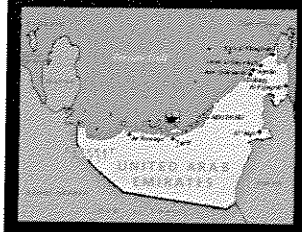
DUBAI



- Foam drilling through the depleted porous Arab Zone Limestone.
- Workovers and re-entries

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F

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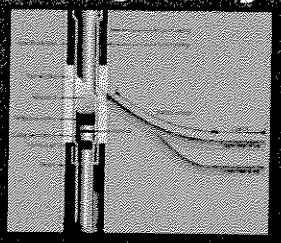
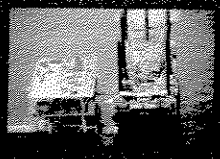
Through Tubing Re-Entry Dubai



- Milled thru both the 4-1/2" and 9-5/8" casing
- Drilled Dual Lateral
- Eliminated the need to pull the completion
- Selectivity acidized both legs with coiled tubing
- Performed all the services with the same unit



REDUCED TOTAL COST TO COMPLETE THE WELL

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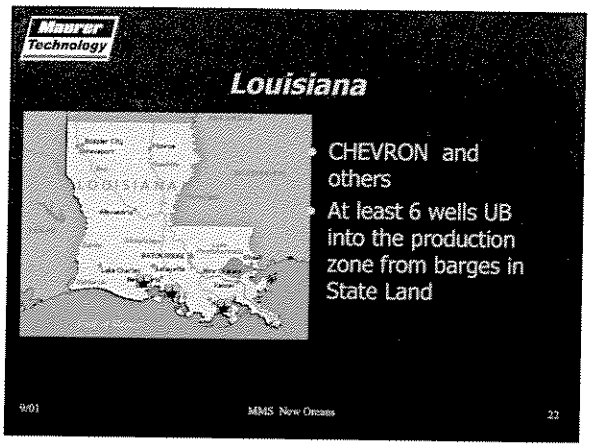
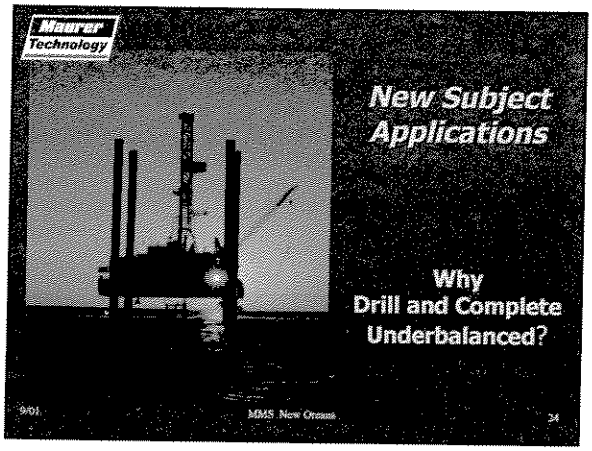
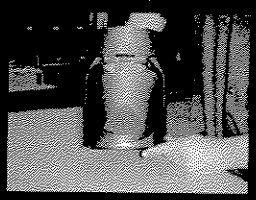


- What Precautions



200 Worldwide UB Horizontal Wells

JARGON



Deployment Valve

- Surging
- Quality
- Gaseated Fluid
- Foam
- Flow Drill
- Mud Cap
- Floating Mud Column
- Top Kill
- Deployment Valve

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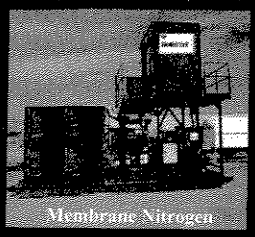
New Term

Well Kick -

Foam - emulsion

JARGON (CONT.)



Membrane Nitrogen

- Pipe Light
- String Float
- Cryogenic Nitrogen
- Membrane Nitrogen
- Unload (the Annulus)
- Stress/compression Failure

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WHERE? (GOM)

- Horizontal into reservoir to reduce skin damage and lower completion cost
- Lost circulation (reduce mud weight)
- By-passed production
- Differential sticking (reduce mud weight)
- Deep water geopressured zones
- DGD applications

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NO! (GOM)

- Long vertical open hole sections
- Massive shale sections
- Salt
- Faulted or slump zones

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Implications of Marine UB Drilling

- **EXTEND PLATFORM LIFE**
- **COST SAVINGS $$$$$**
  - **No lost circulation**
  - **No differential sticking**
  - **Faster drilling rate**
  - **Less formation damage**
  - **Simple completions**
- **IMPROVED RATE OF RETURN**

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* May lead to producing thief zones
  - Bypassed production

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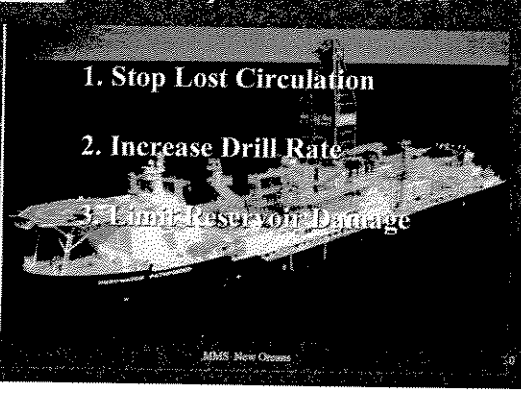
Primary Reasons for UBD

1. Stop Lost Circulation
2. Increase Drill Rate
3. Limit Reservoir Damage



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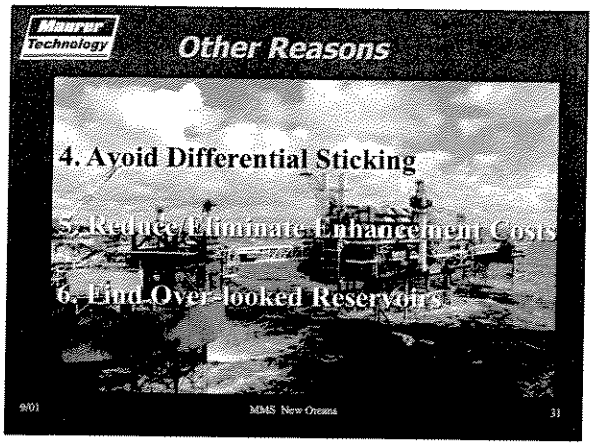
#1 prevention LC


Maurer Technology
Other Reasons
4. Ayoid Differential Sticking
5. Reduce/Eliminate Enhancement Costs
6. Find Over-looked Reservoirs
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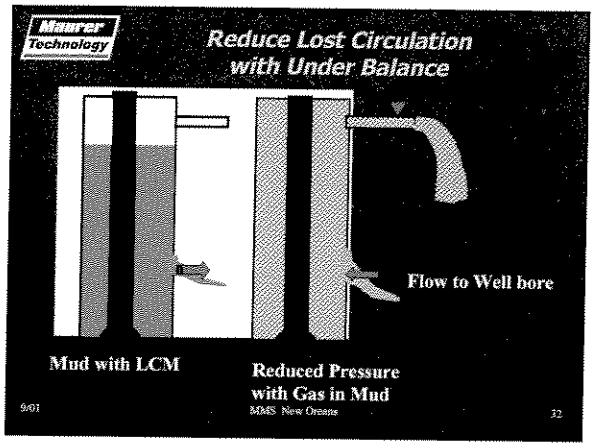
Maurer Technology
Reduce Lost Circulation with Under Balance
Flow to Well bore
Mud with LCM
Reduced Pressure with Gas in Mud
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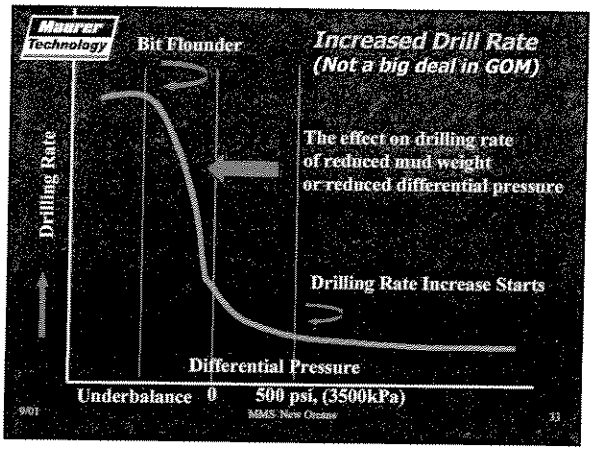
Maurer Technology
Bit Flounder
Increased Drill Rate
(Not a big deal in GOM)
The effect on drilling rate of reduced mud weight or reduced differential pressure
Drilling Rate Increase Starts
Drilling Rate
Differential Pressure
Underbalance 0 500 psi, (3500kPa)
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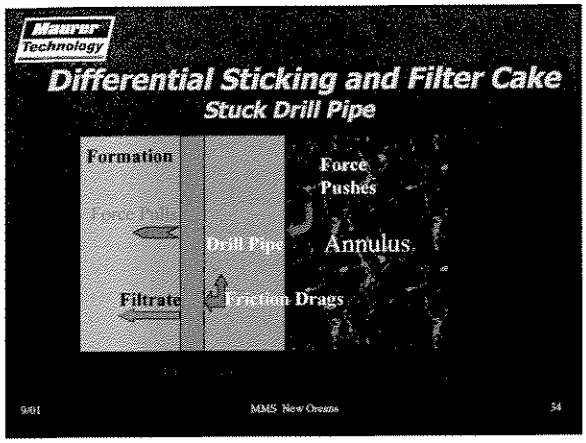
33


Maurer Technology
Differential Sticking and Filter Cake
Stuck Drill Pipe
Formation
Force Pushes
Drill Pipe
Annulus
Filtrate
Friction Drags
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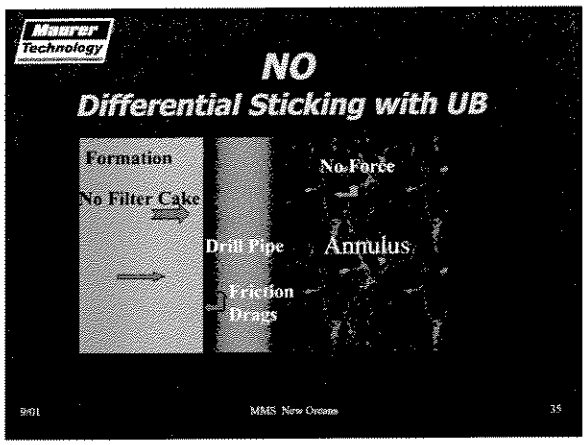
Maurer Technology
NO
Differential Sticking with UB
Formation
No Filter Cake
No Force
Drill Pipe
Annulus
Friction Drags
9/01
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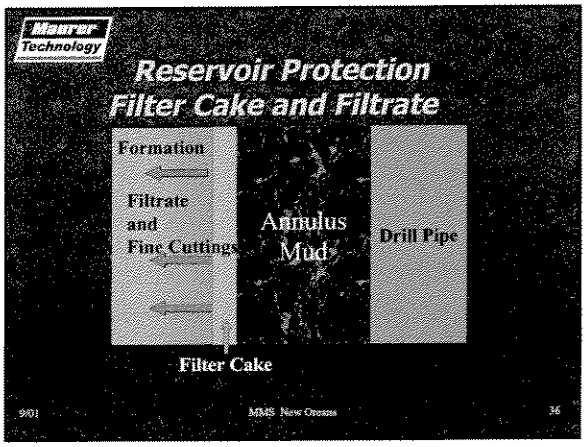
35


Maurer Technology
Reservoir Protection
Filter Cake and Filtrate
Formation
Filtrate and Fine Cuttings
Annulus Mud
Drill Pipe
Filter Cake
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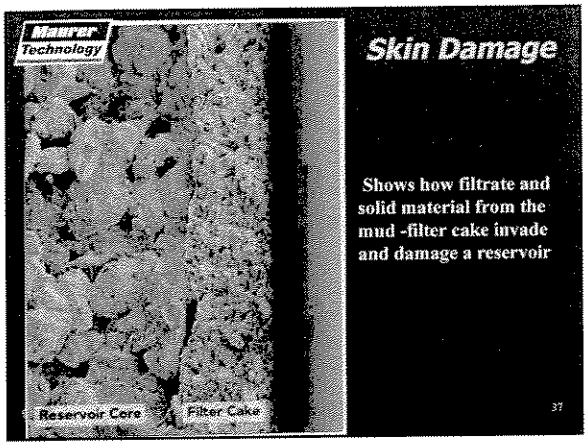
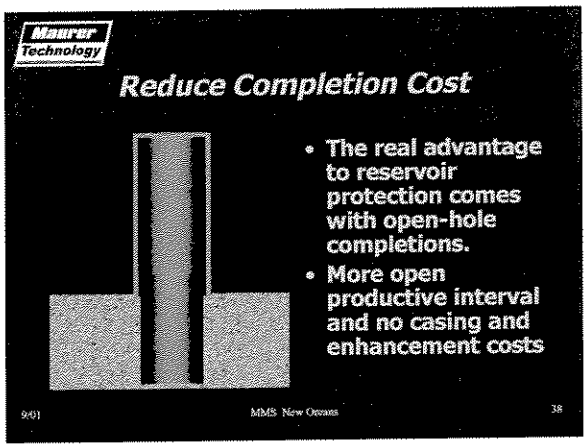

Maurer Technology
Skin Damage
Shows how filtrate and solid material from the mud -filter cake invade and damage a reservoir
Reservoir Core
Filter Cake
37


Maurer Technology
Reduce Completion Cost
• The real advantage to reservoir protection comes with open-hole completions.
• More open productive interval and no casing and enhancement costs
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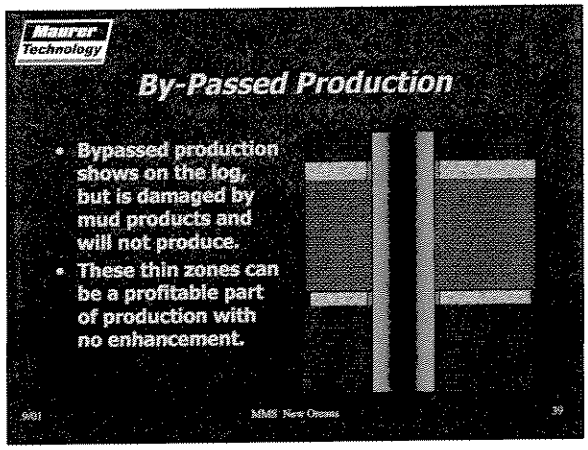
Maurer Technology
By-Passed Production
• Bypassed production shows on the log, but is damaged by mud products and will not produce.
• These thin zones can be a profitable part of production with no enhancement.
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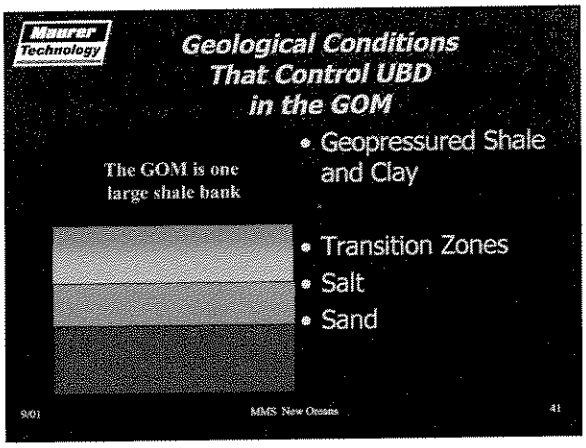
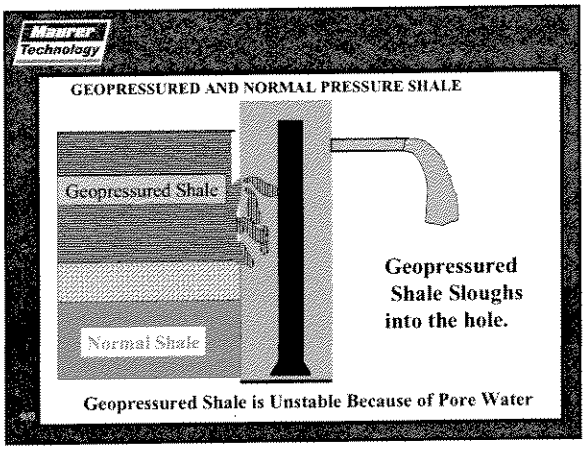
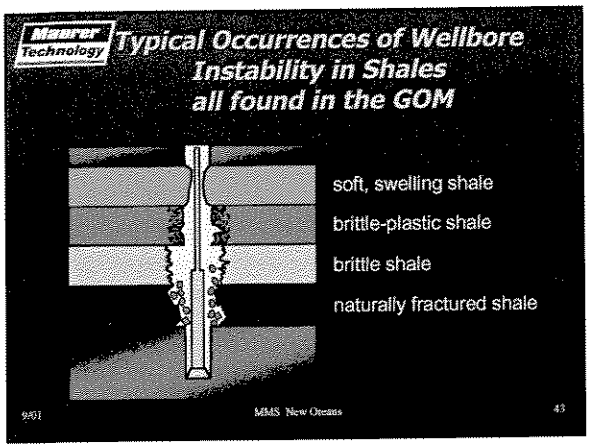


- No UB in Salt !!
Really ~~do~~ avoid salt & sand transition zone



NO UB in geopressured shale


Maurer Technology
Typical Occurrences of Wellbore Instability in Shales all found in the GOM
soft, swelling shale
brittle-plastic shale
brittle shale
naturally fractured shale
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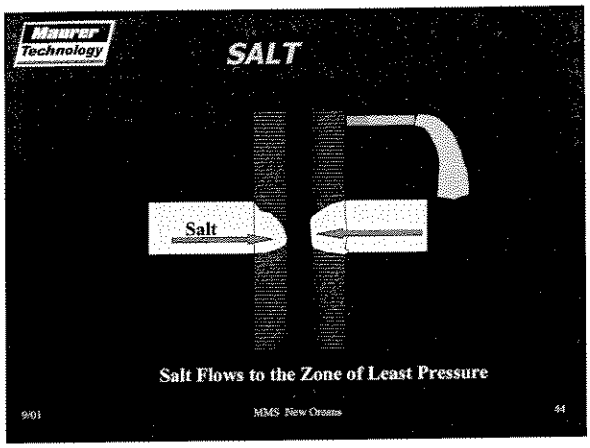
Maurer Technology
SALT
Salt
Salt Flows to the Zone of Least Pressure
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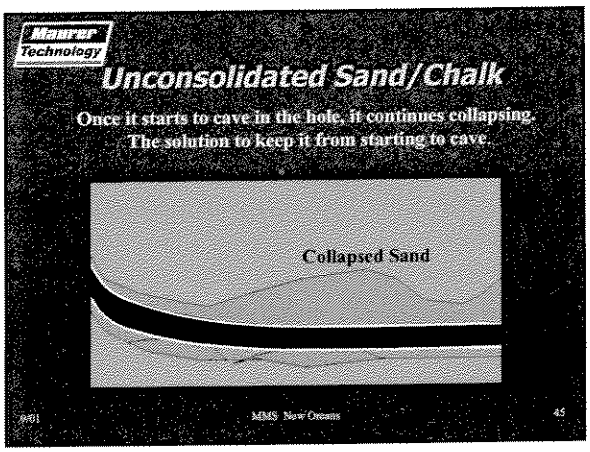
Maurer Technology
Unconsolidated Sand/Chalk
Once it starts to cave in the hole, it continues collapsing.
The solution to keep it from starting to cave.
Collapsed Sand
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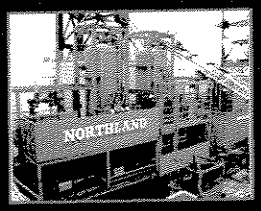
Equipment

Equipment For Near Or Underbalanced Drilling



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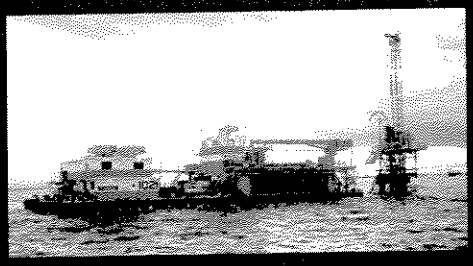
Coiled Tubing or Jointed Tubing?



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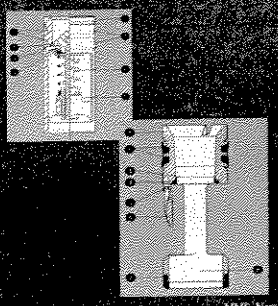
Drill Pipe Float



- Floats are always used in near of UB drilling.
- The string float is only used with drill pipe injection of a gas.

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Underbalance Drilling

Rotating Heads
&
Rotating BOP's

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Manufacturers

- Weatherford/Williams
- Smith/ Grant
- Varco/Shaffer RSBOP
- Precision Drilling/RBOP

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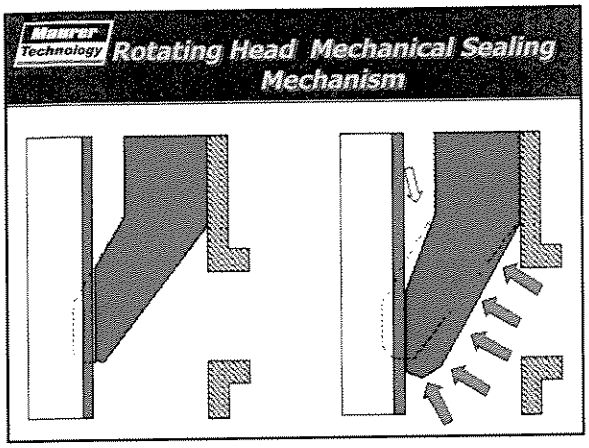
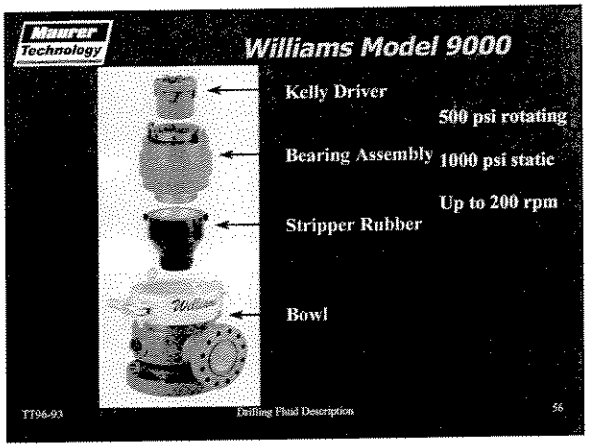
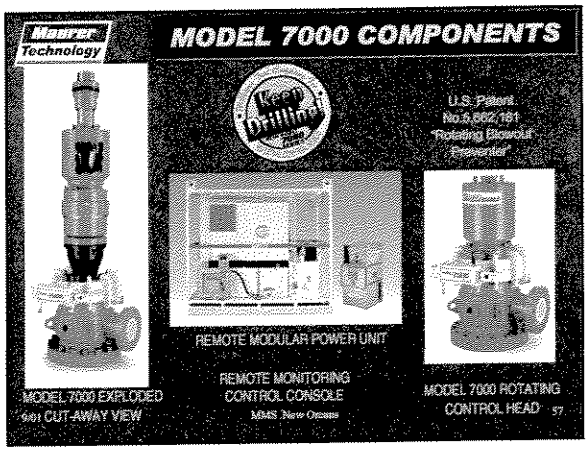
Rotating Head Schematics

Single Element Dual Element

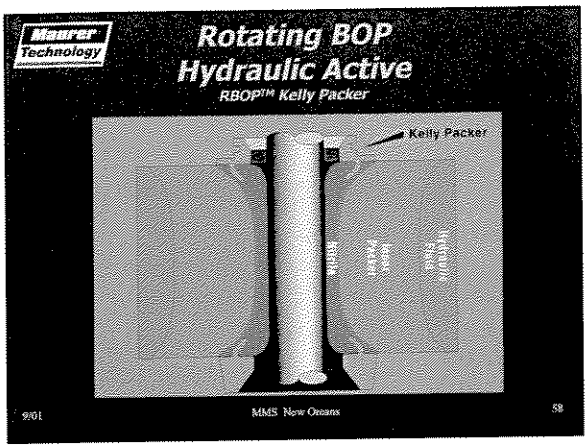






options

Testing RBOP - daily for H_2S
- same as BOP stack
- every trip
-


Maurer Technology
Rotating BOP
Hydraulic Active
RBOP™ Kelly Packer
Kelly Packer
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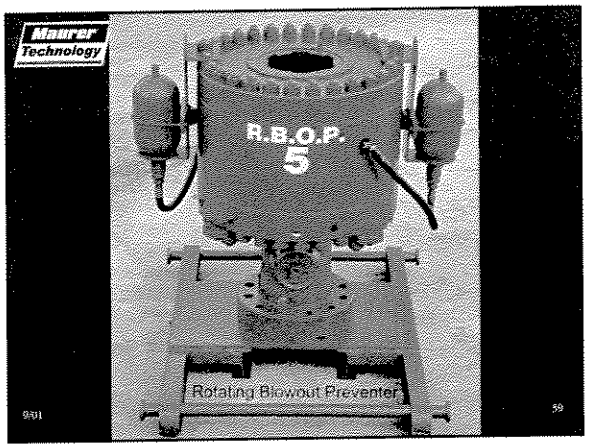
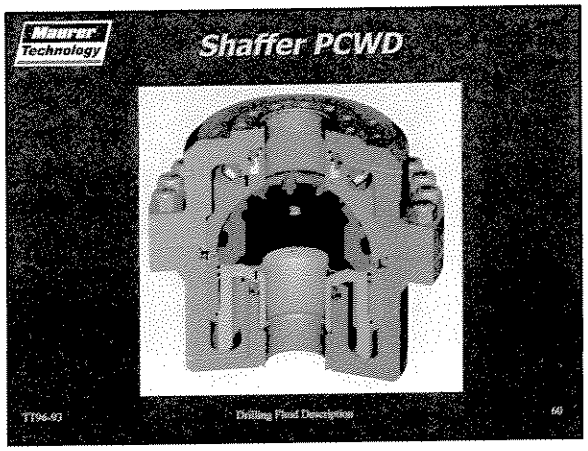
58


Maurer Technology
R.B.O.P.
5
Rotating Blowout Preventer
9/01
59


Maurer Technology
Shaffer PCWD
TT96-93
Drilling Fluid Description
60

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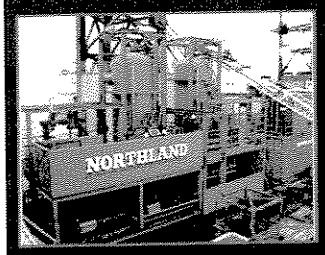
Separators

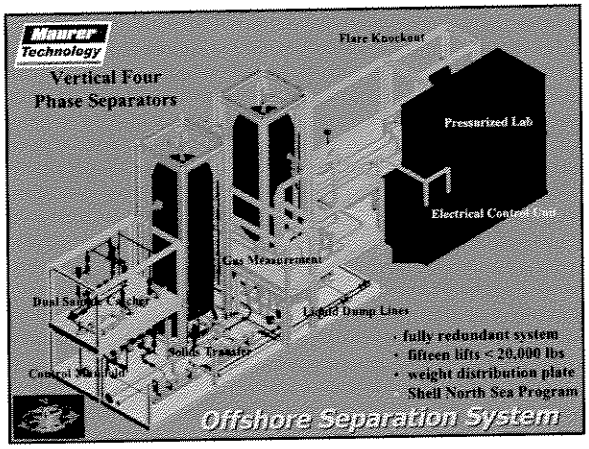


Vary from the simple gas-buster stack found on most rigs to very complex systems.

This is a North Sea system on the Brittanica

Maurer Technology

Vertical Four Phase Separators

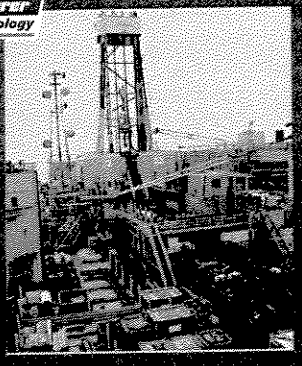


- fully redundant system
- fifteen lifts < 20,000 lbs
- weight distribution plate
- Shell North Sea Program

Offshore Separation System

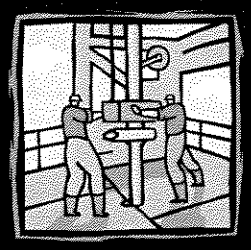
Maurer Technology

LEMAN A27



- Northland Package on Cantilever Deck
- Main Deck left open for Nitrogen Generation Equipment

Mud Systems



- Simpler and with less volume because pipe is set and only the zone is being drilled.
- Typically will be a water base system or a simple oil system.

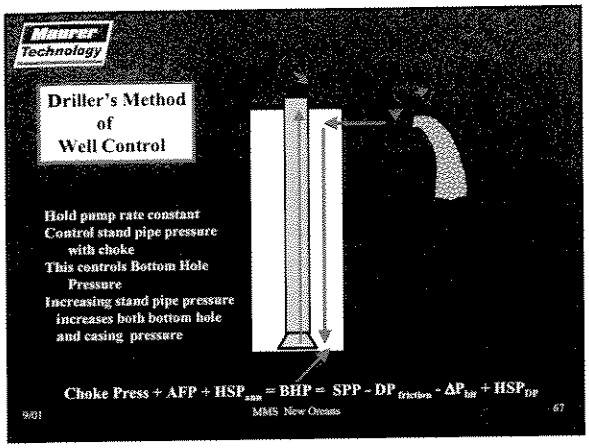
Comments On Well Control

Dr. Jerome Schubert

Comments On Well Control

Drillers Method

Well Control For UBD


Maurer Technology
Driller's Method of Well Control
Hold pump rate constant
Control stand pipe pressure with choke
This controls Bottom Hole Pressure
Increasing stand pipe pressure increases both bottom hole and casing pressure
Choke Press + AFP + HSP$_{ann}$ = BHP = SPP - DP$_{friction}$ - ΔP$_{bit}$ + HSP$_{DP}$
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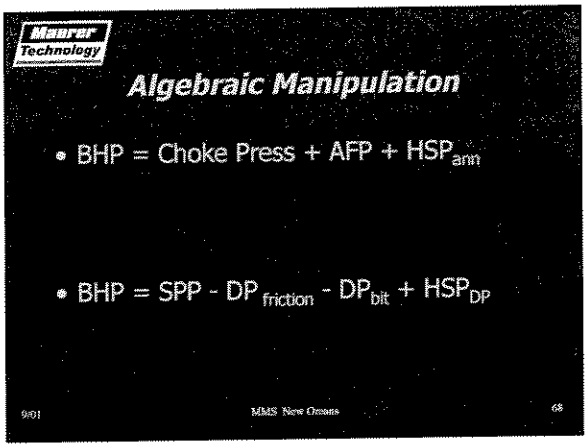
Maurer Technology
Algebraic Manipulation
• BHP = Choke Press + AFP + HSP$_{ann}$
• BHP = SPP - DP$_{friction}$ - DP$_{bit}$ + HSP$_{DP}$
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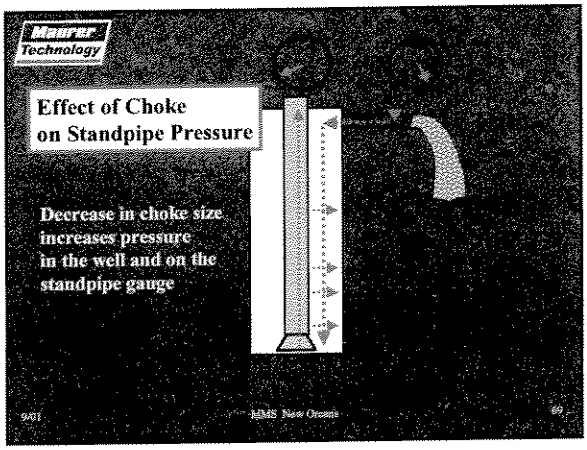
Maurer Technology
Effect of Choke on Standpipe Pressure
Decrease in choke size increases pressure in the well and on the standpipe gauge
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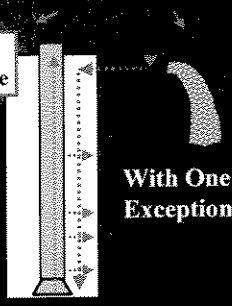
UBD Well Control

- Goal is to maintain a constant BHP somewhat less than Formation Pore Pressure.
- Controlled by Annulus Choke Pressure
- Monitored by constant Standpipe Pressure and Circulation Rate

Maurer Technology

Effect of Choke on Standpipe Pressure

Decrease in choke size increases pressure in the well and on the standpipe gauge



With One Exception

Maurer Technology

Exception

- When sonic velocity has been reached at the bit:
  - A change in pressure downstream of the bit (BHP) will not be reflected upstream of the bit (SPP)
- But, jets in the bit are usually sized where sonic velocity is usually not reached.

UBD Well Control

- Primary Well Control is a combination of:
  - HSP and
  - Surface Equipment
- Secondary Well Control is achieved by use of the BOP stack –
  - Annular and
  - Ram Preventers

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Well Control

CHOKE PRESSURE

- In UB drilling and completions, the well is always under control.
- Pressure at the surface does not mean that the well is not under control

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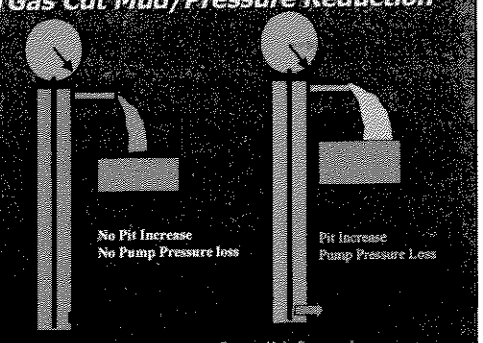
Gas Cut Mud/Pressure Reduction



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Maurer Technology
New Subject
TYPES
OF UNDERBALANCED
SYSTEMS
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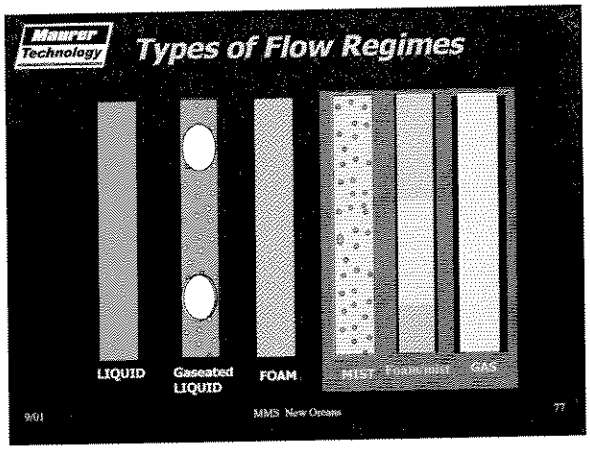
Maurer Technology
Types of Flow Regimes
LIQUID
Gaseated LIQUID
FOAM
MIST
Emulsion
GAS
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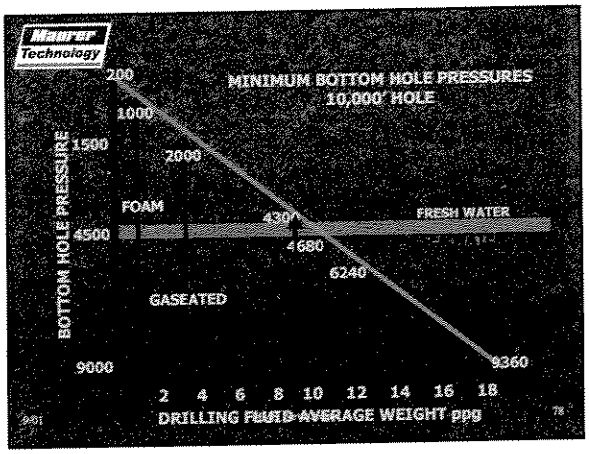
Maurer Technology
MINIMUM BOTTOM HOLE PRESSURES
10,000' HOLE
BOTTOM HOLE PRESSURE
200
1000
1500
2000
4500
9000
FOAM
430
FRESH WATER
4680
6240
GASEATED
9360
2 4 6 8 10 12 14 16 18
DRILLING FLUID AVERAGE WEIGHT ppg
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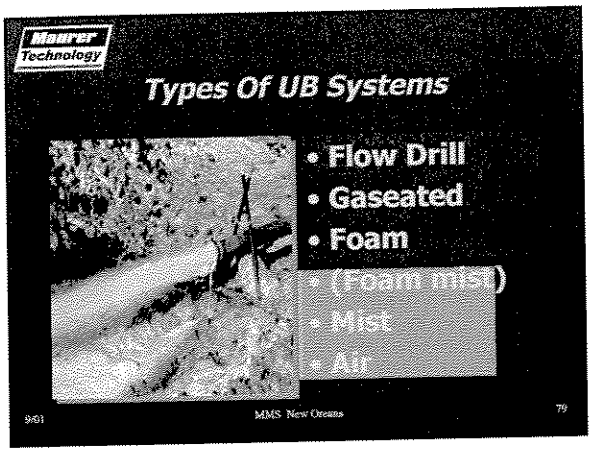
78


Maurer Technology
Types Of UB Systems
• Flow Drill
• Gaseated
• Foam
• (Foam mist)
• Mist
• Air
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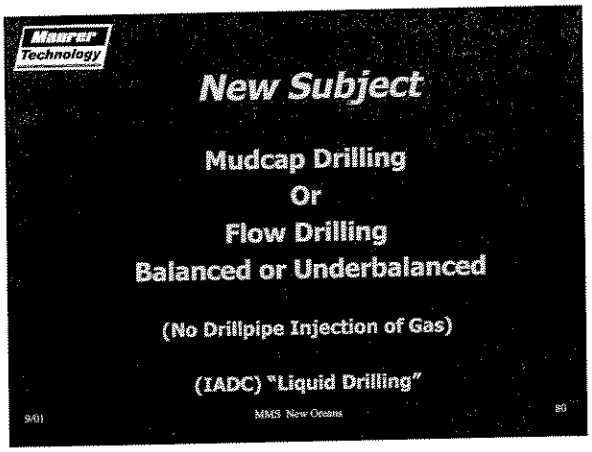
Maurer Technology
New Subject
Mudcap Drilling
Or
Flow Drilling
Balanced or Underbalanced
(No Drillpipe Injection of Gas)
(IADC) "Liquid Drilling"
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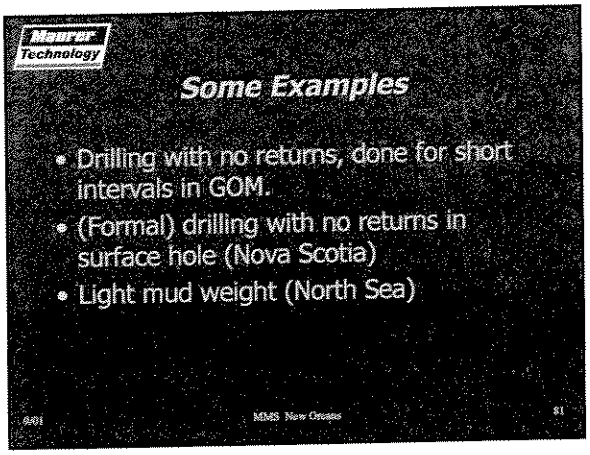
Maurer Technology
Some Examples
• Drilling with no returns, done for short intervals in GOM.
• (Formal) drilling with no returns in surface hole (Nova Scotia)
• Light mud weight (North Sea)
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Maurer Technology
Liquid Drilling Advantages
• Simple
• Minimum Extra Equipment
• Minimum Extra Cost
• LIMITED BY MINIMUM MUD WEIGHT
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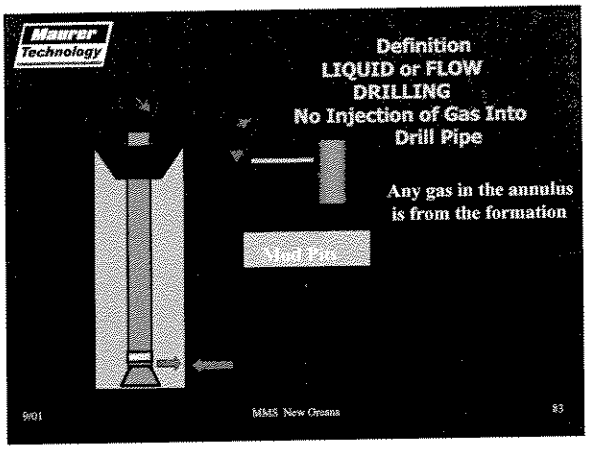
Maurer Technology
Definition
LIQUID or FLOW DRILLING
No Injection of Gas Into Drill Pipe
Any gas in the annulus is from the formation
Mud Pits
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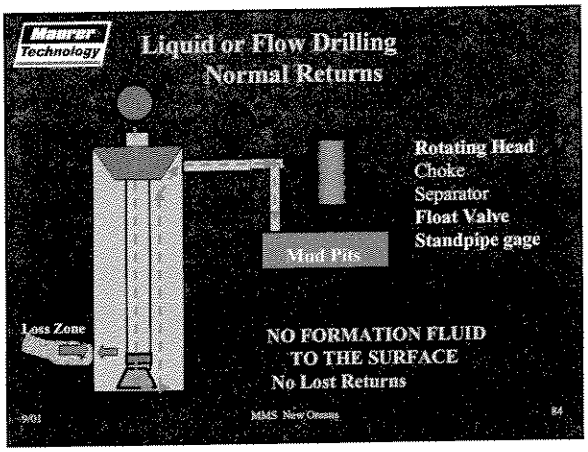
Maurer Technology
Liquid or Flow Drilling
Normal Returns
Rotating Head
Choke
Separator
Float Valve
Standpipe gage
Mud Pits
Loss Zone
NO FORMATION FLUID TO THE SURFACE
No Lost Returns
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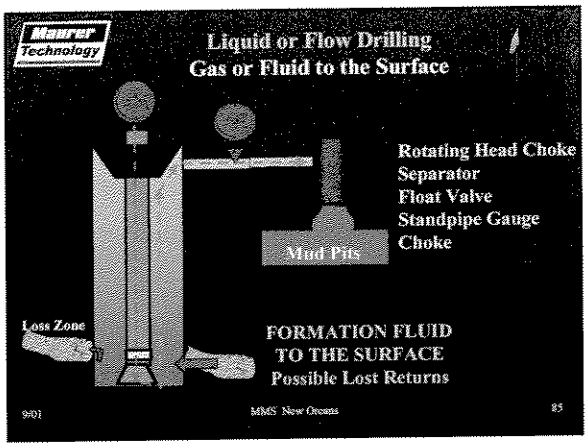
Maurer Technology
Liquid or Flow Drilling
Gas or Fluid to the Surface
Rotating Head Choke
Separator
Float Valve
Standpipe Gauge
Choke
Mud Pits
Loss Zone
FORMATION FLUID
TO THE SURFACE
Possible Lost Returns
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MMS New Orleans
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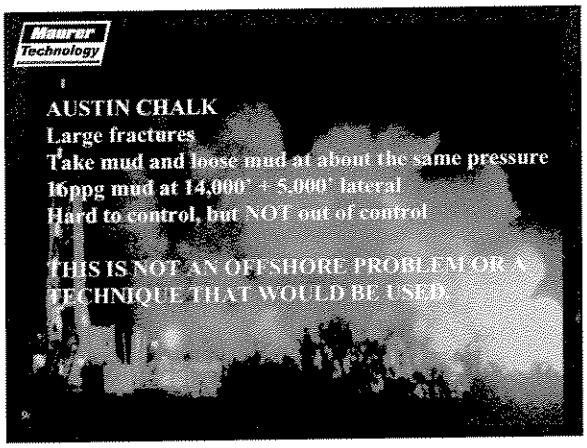
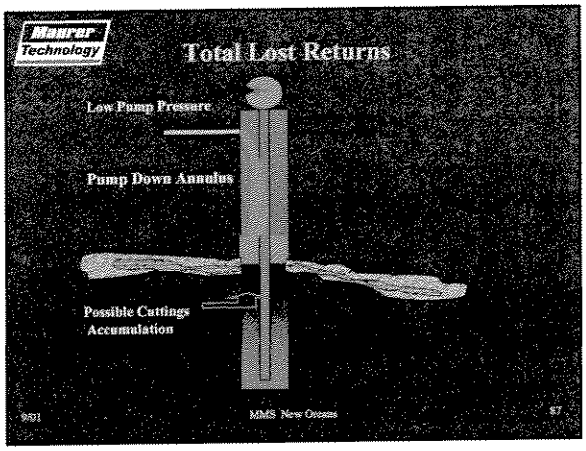

Maurer Technology
AUSTIN CHALK
Large fractures
Take mud and loose mud at about the same pressure
16ppg mud at 14,000' + 5,000' lateral
Hard to control, but NOT out of control
THIS IS NOT AN OFFSHORE PROBLEM OR A TECHNIQUE THAT WOULD BE USED


Maurer Technology
Total Lost Returns
Low Pump Pressure
Pump Down Annulus
Possible Cuttings Accumulation
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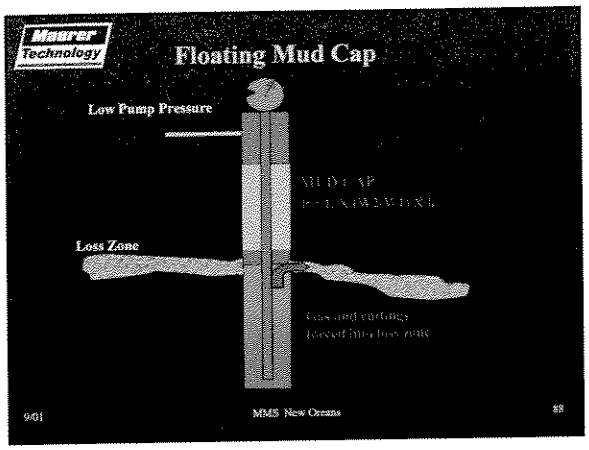
Maurer Technology
Floating Mud Cap
Low Pump Pressure
Loss Zone
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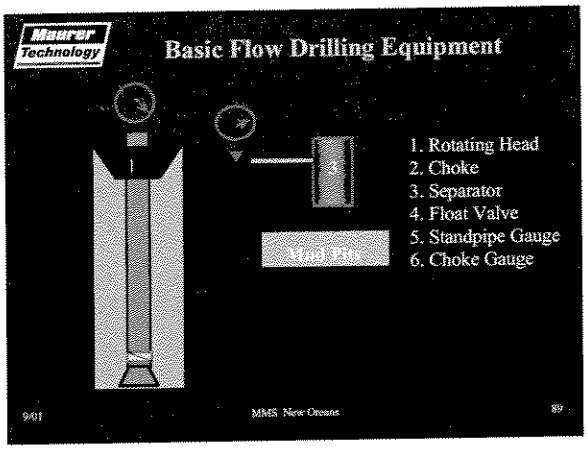
Maurer Technology
Basic Flow Drilling Equipment
1. Rotating Head
2. Choke
3. Separator
4. Float Valve
5. Standpipe Gauge
6. Choke Gauge
Mud Pits
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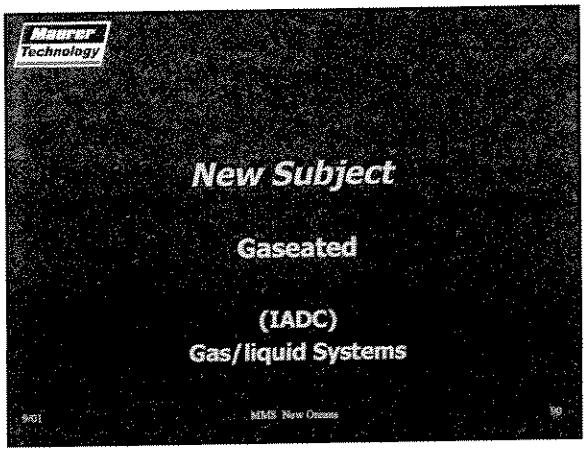
Maurer Technology
New Subject
Gaseated
(IADC)
Gas/liquid Systems
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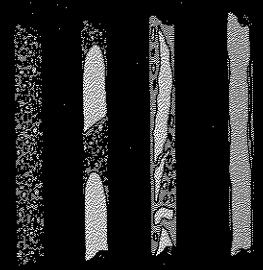
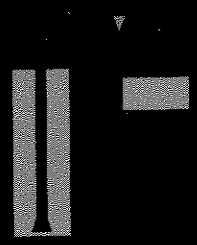
Gaseated Systems Advantages



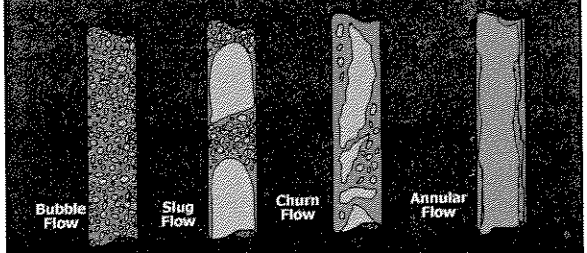
- Reduced Bottom Hole Pressure
- Use Any Type of Mud or Fluid
- Not Temperature Limited

Mud Is Displaced By Gas



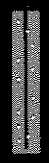
- The displacement of mud by gas makes the mud column lighter
- Measure the mud displaced into the pits as a measure of static hydrostatic loss
- (Flowing friction adds to bottom hole pressure)

Liquid Gas Separation



As the amount of gas increases, the gas starts to separate from the liquid

Limits To Gas Additions



5/1
Gas/Liquid

Lower Ratio Is
Not Effective

50/1
Gas/Liquid

Higher Ratio Is
Too Unstable

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Not Temperature Sensitive

175C 350F

- No special gaseated chemical
- Temperature sensitivity limited to mud products
- Mud can be water or oil

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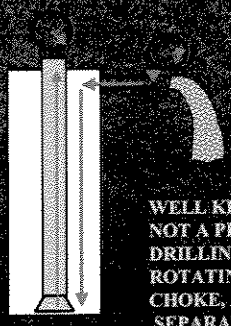
Driller's Method of Well Control

1. Hold pump rate constant
2. Control standpipe pressure
3. With choke
4. This controls bottom hole pressure
5. Increasing standpipe pressure increases both bottom hole and casing pressure



WELL KICKS ARE NOT A PROBLEM DRILLING WITH ROTATING HEAD, CHOKE, AND SEPARATOR and little or no open hole.

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Well Kicks

- Flow drilling with the proper equipment, the definition of Well kick needs to be changed.
- Well Kick is an uncontrolled discharge of gas or fluid from a well.

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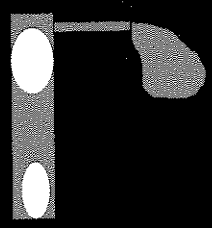
Gaseated Problems



- Surging
  - Causes well bore instability
  - Hard to control BHP
- Unstable on connections
- Loses all air on trips
- Corrosion

All of this due to loose mixture of gas and fluid

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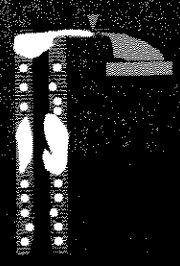
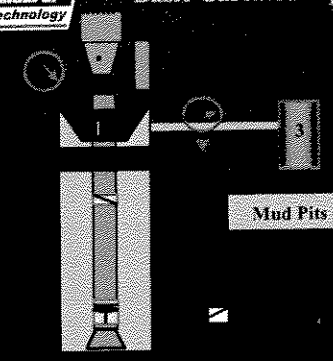
Gaseated Fluids Head



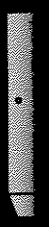
- Surging or heading is part of the gaseated system
- The gas and liquid separate depending on the amount of gas and the fluid velocity
- It can be modified, not stopped

Basic Gaseated Equipment



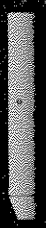
1. Rotating Head, Rotating BOP
2. Choke
3. Separator
4. Press. Flow Line
5. Standpipe Manf.
6. Bit Float
7. String Float
8. Lower Kelly Cock
9. Compressor Lines
10. Compressor

Special Equipment Limit Surging



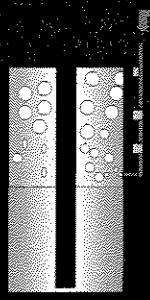
- Boosting on connections
- Jet sub
- Parasite string
- Dual casing
- Other ideas have been tried

Jet Sub



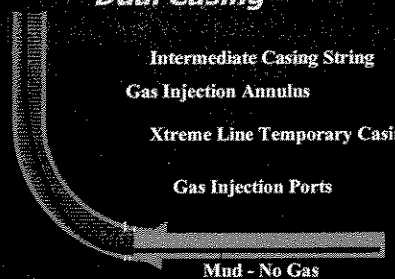
- Basic Drill Pipe Sub
- Bit Jet generally about 11/32" (17mm)
- Place at about 3000' (900m)
- Most common practice

Parasite String



- 2-3" Tubing
- Run with surface pipe
- Tubing banded to the surface pipe
- Gas injected only in the tubing

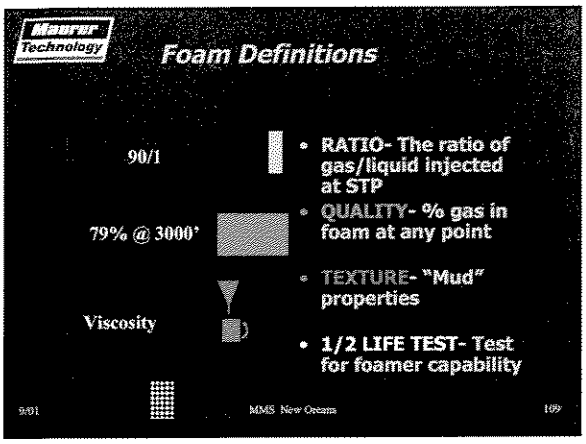
Dual Casing



- Intermediate Casing String
- Gas Injection Annulus
- Xtreme Line Temporary Casing
- Gas Injection Ports
- Mud - No Gas

Equipment Rule

- WHAT IS NEEDED
  - What is nice to have, gets you in trouble!
- COUNT BARRIERS TO EACH POSSIBLE PROBLEM


Maurer Technology
Foam Definitions
90/1
79% @ 3000'
Viscosity
• RATIO- The ratio of gas/liquid injected at STP
• QUALITY- % gas in foam at any point
• TEXTURE- "Mud" properties
• 1/2 LIFE TEST- Test for foamer capability
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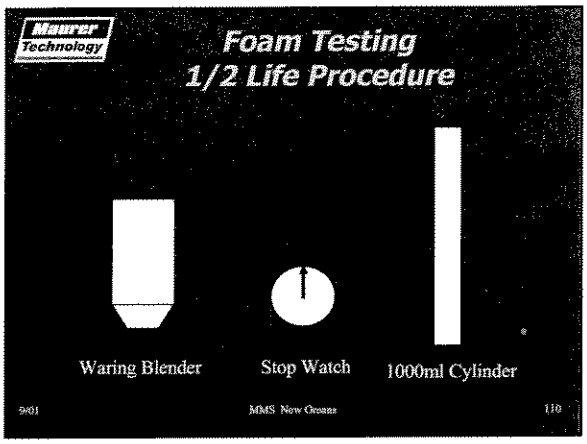
Maurer Technology
Foam Testing
1/2 Life Procedure
Waring Blender
Stop Watch
1000ml Cylinder
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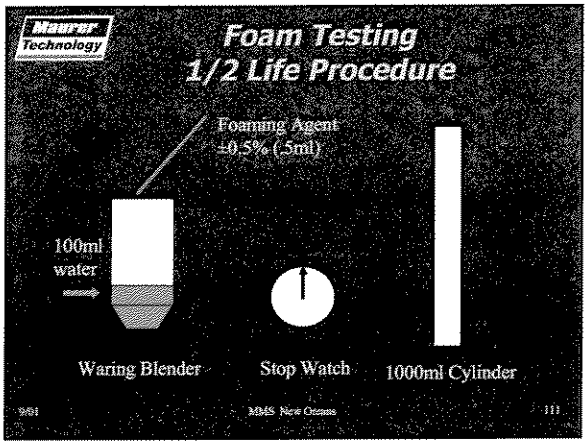
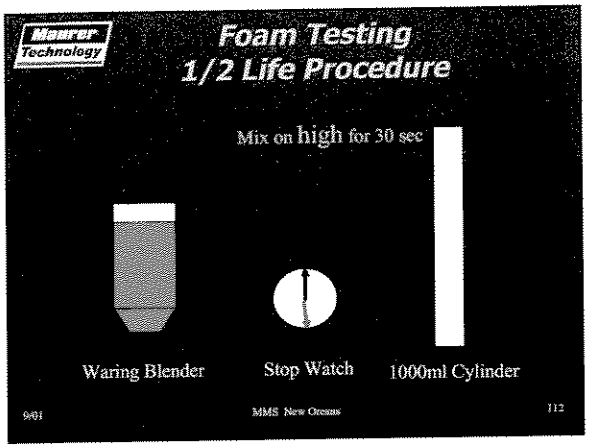

Maurer Technology
Foam Testing
1/2 Life Procedure
Foaming Agent
±0.5% (.5ml)
100ml
water
Waring Blender
Stop Watch
1000ml Cylinder
9/01
MMS New Orleans
111


Maurer Technology
Foam Testing
1/2 Life Procedure
Mix on high for 30 sec
Waring Blender
Stop Watch
1000ml Cylinder
9/01
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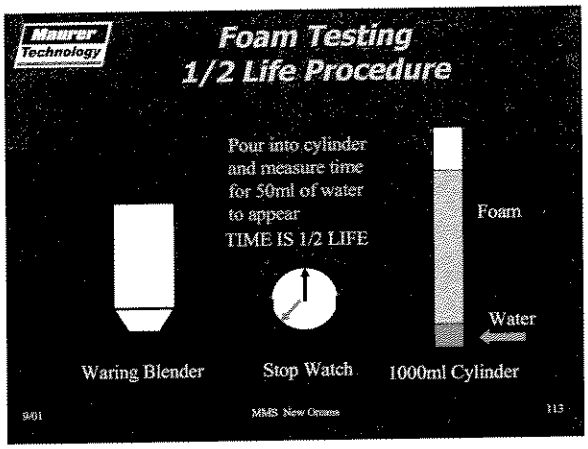
Maurer Technology
Foam Testing
1/2 Life Procedure
Pour into cylinder
and measure time
for 50ml of water
to appear
TIME IS 1/2 LIFE
Foam
Water
Waring Blender
Stop Watch
1000ml Cylinder
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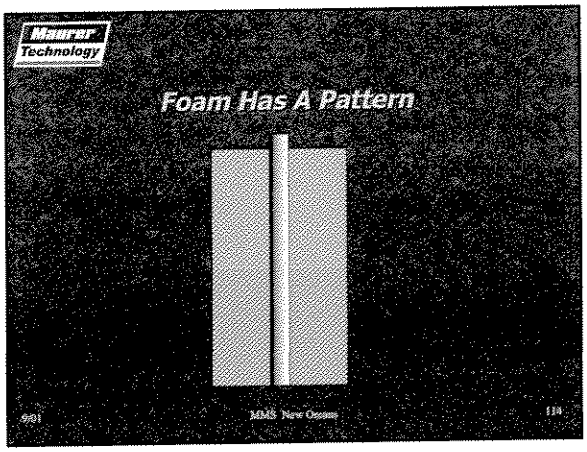
Maurer Technology
Foam Has A Pattern
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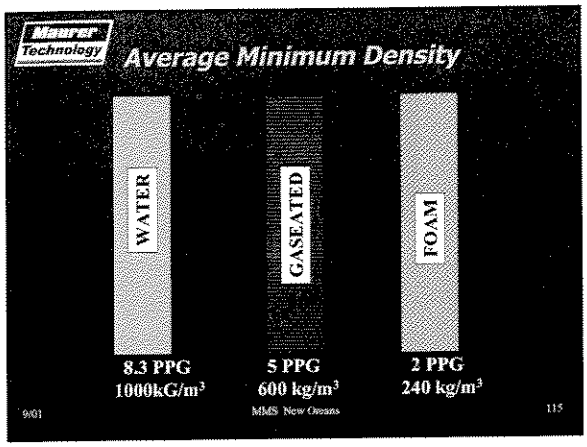
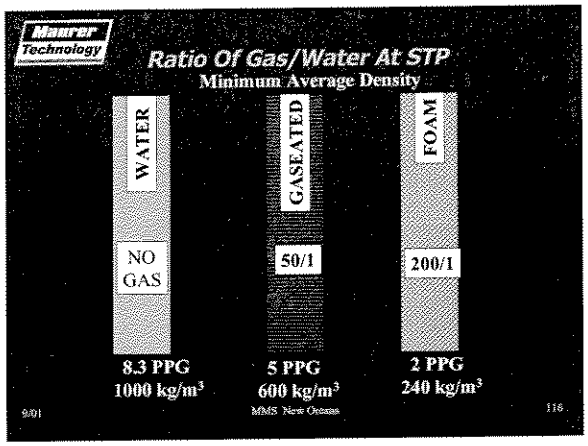
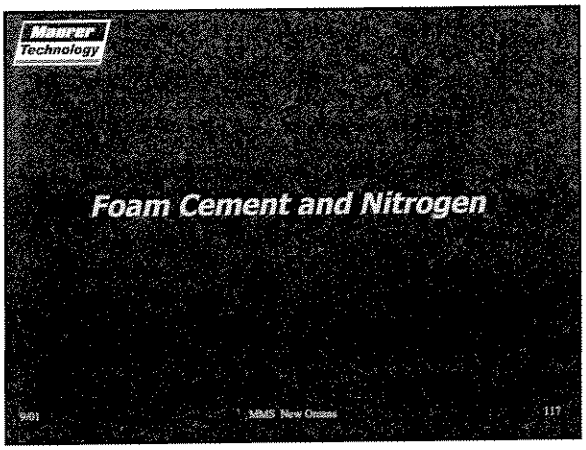

Maurer Technology
Average Minimum Density
WATER
GASEATED
FOAM
8.3 PPG
1000kG/m3
5 PPG
600 kg/m3
2 PPG
240 kg/m3
MMS New Orleans
9/01
115


Maurer Technology
Ratio Of Gas/Water At STP
Minimum Average Density
WATER
NO GAS
GASEATED
50/1
FOAM
200/1
8.3 PPG
1000 kg/m3
5 PPG
600 kg/m3
2 PPG
240 kg/m3
MMS New Orleans
9/01
116

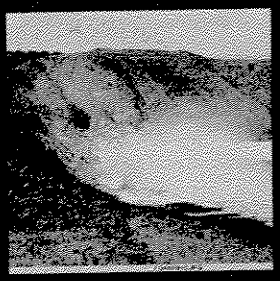

Maurer Technology
Foam Cement and Nitrogen
MMS New Orleans
9/01
117

Foam Advantages

- Limit Reservoir Damage
- Stop Lost Circulation
- Increase Drill Rate
- Stop Differential Sticking
- Expose Overlooked Reservoirs

9/01 MMS New Orleans 118

Advantages To Foam(2)



- Workovers
- Low water requirements
- Low corrosion
- Environmentally OK Quick Breakdown

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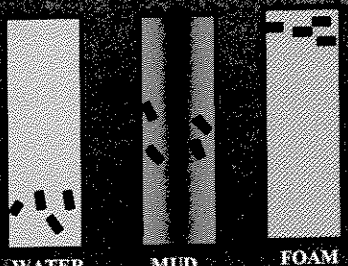
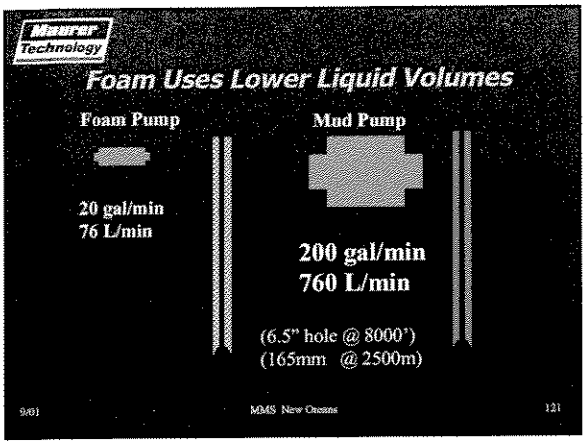
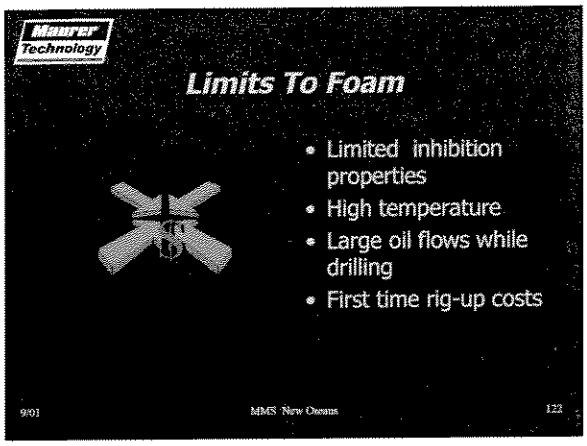
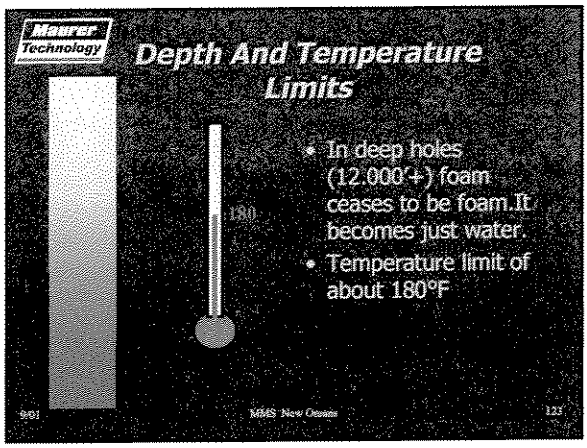
Lifting Capacity Of Foam

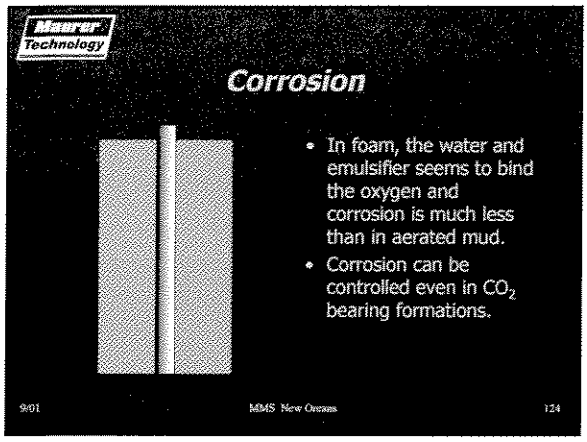


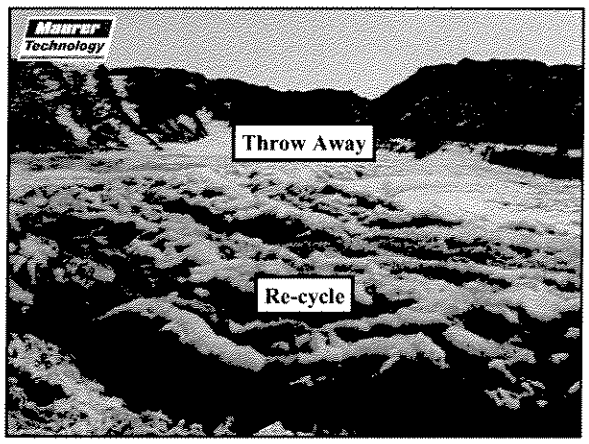
9/01 MMS New Orleans 120

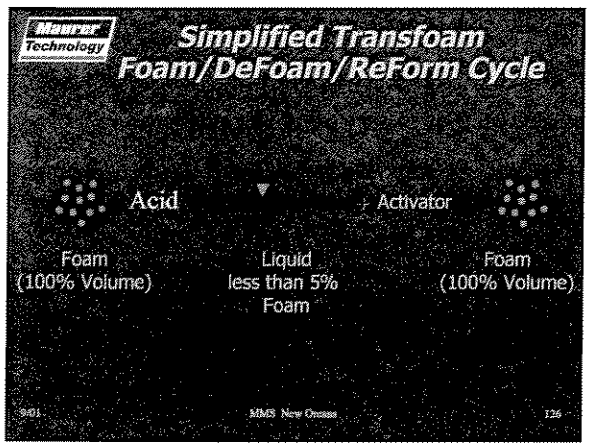

Maurer Technology
Foam Uses Lower Liquid Volumes
Foam Pump
Mud Pump
20 gal/min
76 L/min
200 gal/min
760 L/min
(6.5" hole @ 8000')
(165mm @ 2500m)
9/01
MMS New Orleans
121


Maurer Technology
Limits To Foam
• Limited inhibition properties
• High temperature
• Large oil flows while drilling
• First time rig-up costs
9/01
MMS New Orleans
123

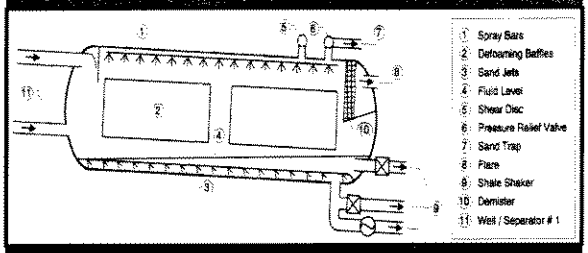

Maurer Technology
Depth And Temperature Limits
180
• In deep holes (12.000'+) foam ceases to be foam.It becomes just water.
• Temperature limit of about 180°F
9/01
MMS New Orleans
122


Maurer Technology
Corrosion
• In foam, the water and emulsifier seems to bind the oxygen and corrosion is much less than in aerated mud.
• Corrosion can be controlled even in CO_2 bearing formations.
9/01
MMS New Orleans
124


Maurer Technology
Throw Away
Re-cycle


Maurer Technology
Simplified Transfoam
Foam/DeFoam/ReForm Cycle
Acid
Activator
Foam
(100% Volume)
Liquid
less than 5%
Foam
Foam
(100% Volume)
9/01
MMS New Orleans
126

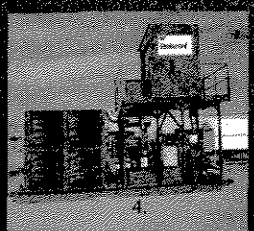
Maurer Technology — Foam Mechanical Recirculation Separator (Hanking and Rappuhn, 1996)



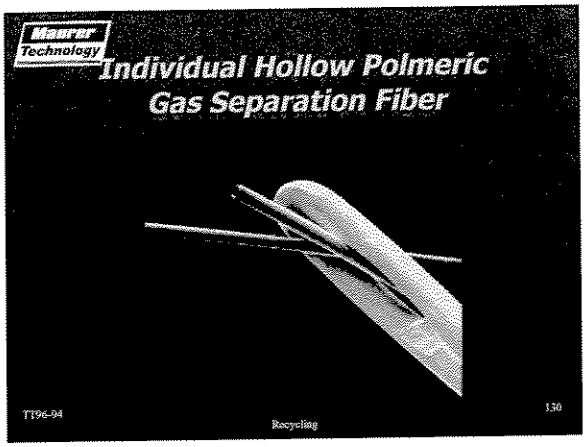
Maurer Technology — Gases For UB Drilling

- **Membrane Nitrogen**
- **Cryogenic nitrogen** - heavy equipment with limited volume capacity
- **Air** - fire danger and corrosion
- **Natural Gas** - possibly the best choice, but not used because of ??

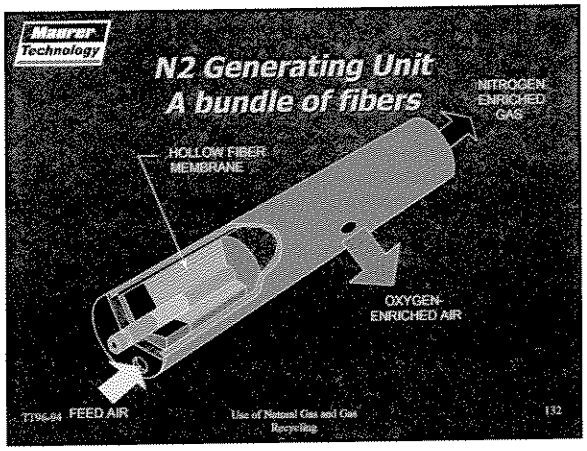
Maurer Technology — Weatherford 2000 Nitrogen Generation Unit

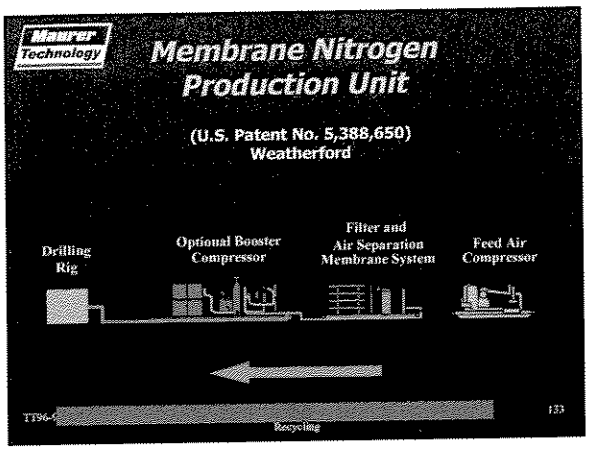


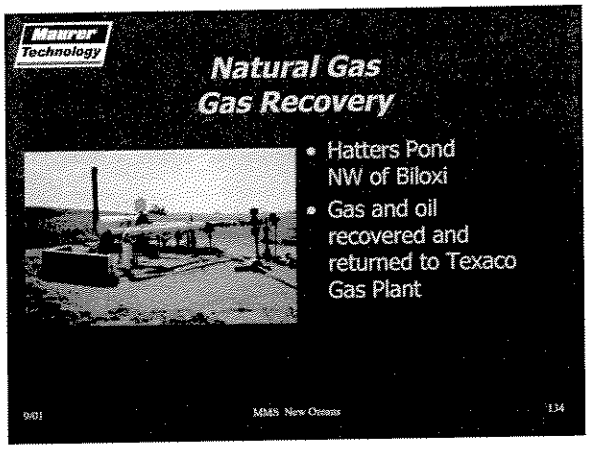
- 1. N_2 500-600scfm
- 2. 2000 psi comp.
- 3. 27 gph diesel
- 4. 8'X20"X16' high
- Nominal O_2 5%

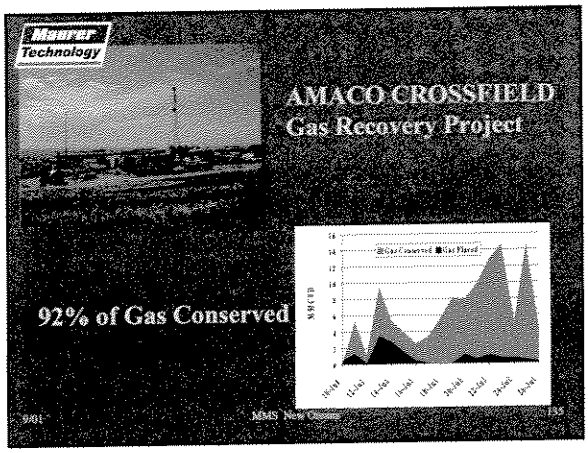

Maurer Technology
Individual Hollow Polmeric Gas Separation Fiber
TT96-94
Recycling
130


Maurer Technology
Individual Hollow Polmeric Gas Separation Fiber
Nitrogen
Oxygen
Water Vapor
Nitrogen
Feed Air
Oxygen and Water Vapor Are "Fast" Gases Which Quickly Permeate the Membrane, Allowing Nitrogen to Flow Through the Fiber Bores as the Product Stream
TT96-94
Use of Natural Gas and Gas Recycling
131


Maurer Technology
N2 Generating Unit
A bundle of fibers
NITROGEN-ENRICHED GAS
HOLLOW FIBER MEMBRANE
OXYGEN-ENRICHED AIR
FEED AIR
TT96-94
Use of Natural Gas and Gas Recycling
132


Maurer Technology
Membrane Nitrogen Production Unit
(U.S. Patent No. 5,388,650)
Weatherford
Drilling Rig
Optional Booster Compressor
Filter and Air Separation Membrane System
Feed Air Compressor
Recycling
133


Maurer Technology
Natural Gas Gas Recovery
• Hatters Pond NW of Biloxi
• Gas and oil recovered and returned to Texaco Gas Plant
9/01
MMS New Orleans
134

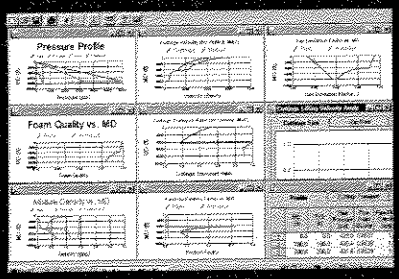

Maurer Technology
AMACO CROSSFIELD
Gas Recovery Project
92% of Gas Conserved
MMCFD
9/01
MMS New Orleans

Maurer Technology

New Subject Calculations For UB Drilling

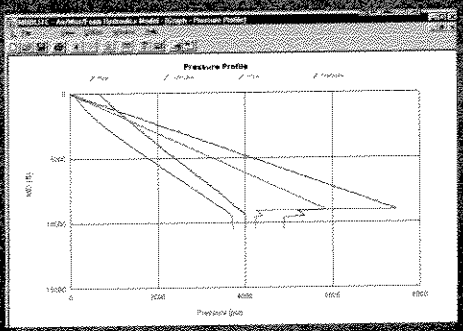
Maurer Technology

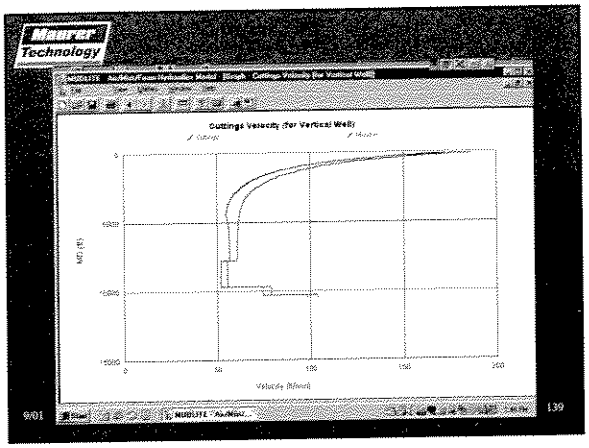
Calculations Of Foam Flow

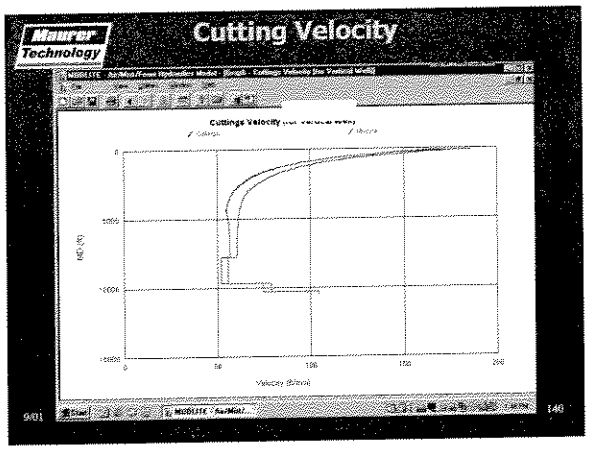


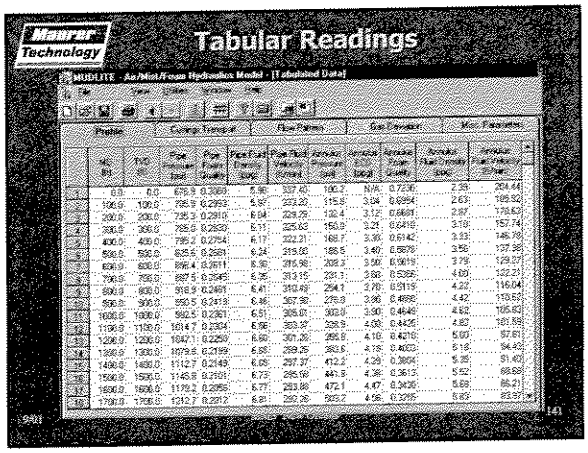
Maurer Technology

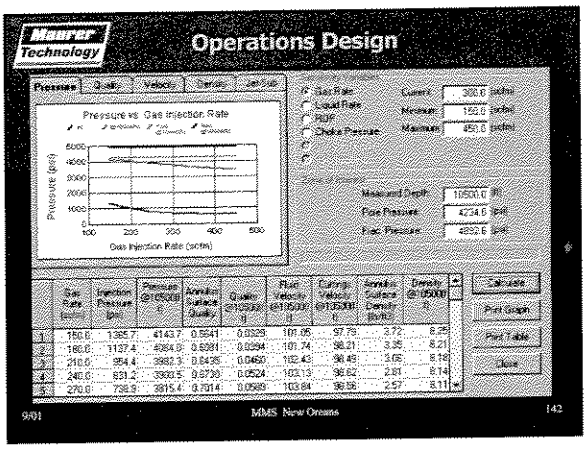
Pressure Profile

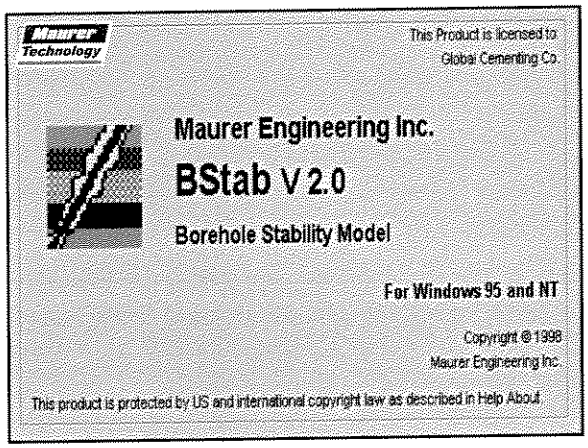


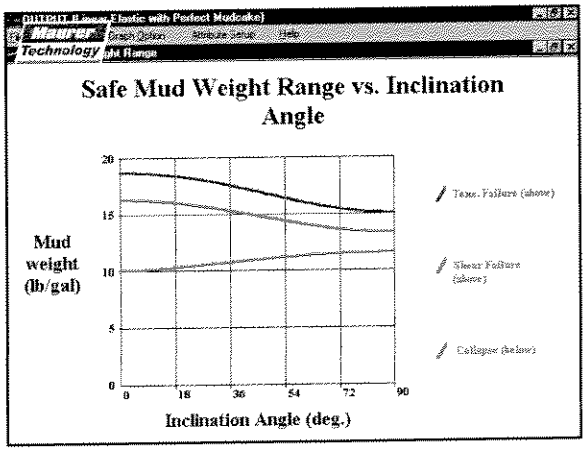

Maurer Technology
Cuttings Velocity (for Vertical Well)
9/01
139

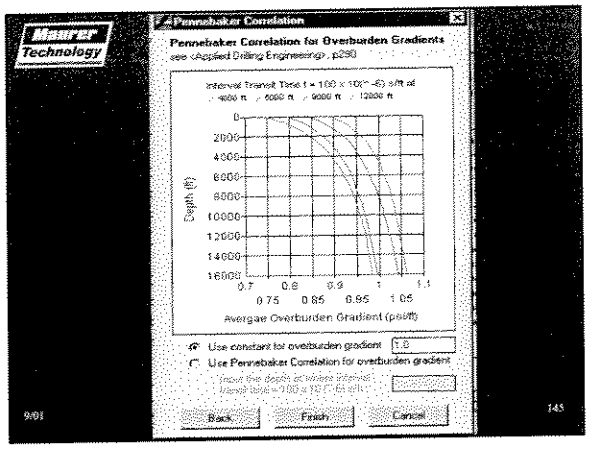

Maurer Technology
Cutting Velocity
9/01
146

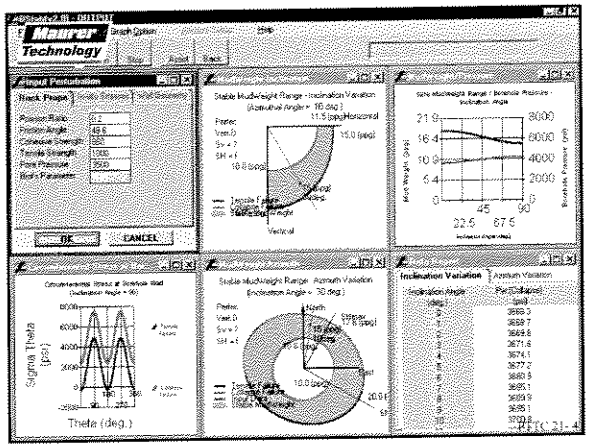

Maurer Technology
Tabular Readings
9/01
143

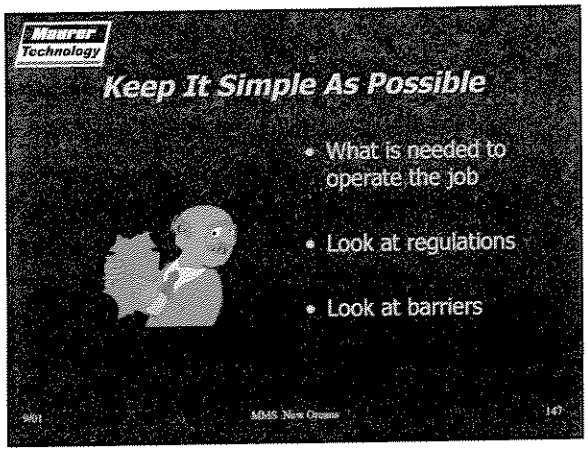

Maurer Technology
Operations Design
Pressure vs. Gas Injection Rate
Pressure (psig)
Gas Injection Rate (scfm)
9/01
MMS New Orleans
142

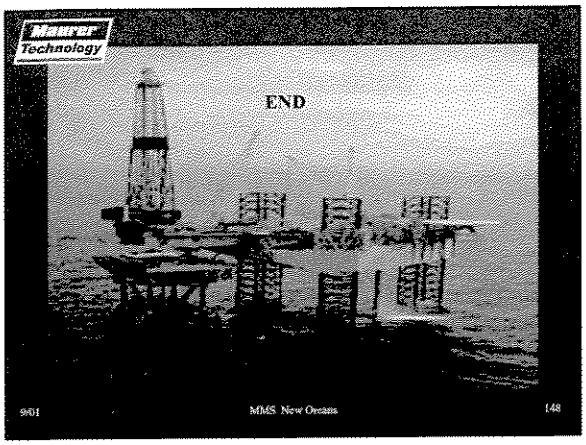

Maurer Technology
This Product is licensed to:
Global Cementing Co.
Maurer Engineering Inc.
BStab V 2.0
Borehole Stability Model
For Windows 95 and NT
Copyright © 1998
Maurer Engineering Inc.
This product is protected by US and international copyright law as described in Help About

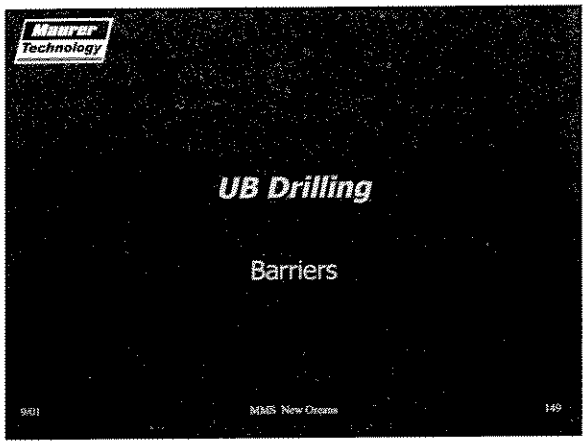

Maurer Technology
Safe Mud Weight Range vs. Inclination Angle
Mud weight (lb/gal)
Inclination Angle (deg.)
0
5
10
15
20
0
18
36
54
72
90

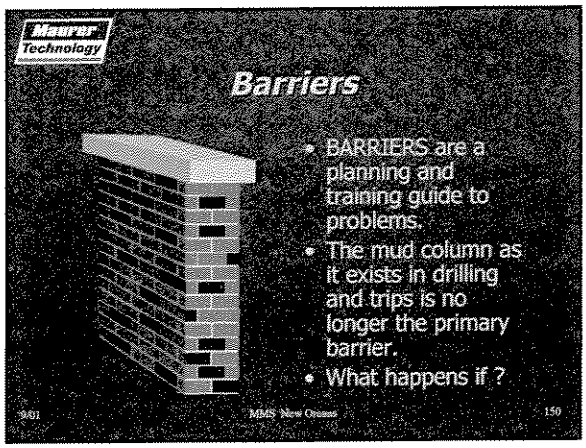

Maurer Technology
Pennebaker Correlation
Pennebaker Correlation for Overburden Gradients
see <Applied Drilling Engineering>, p290
Depth (ft)
Average Overburden Gradient (psi/ft)
Use constant for overburden gradient
Use Pennebaker Correlation for overburden gradient
Back
Finish
Cancel
9/01
145

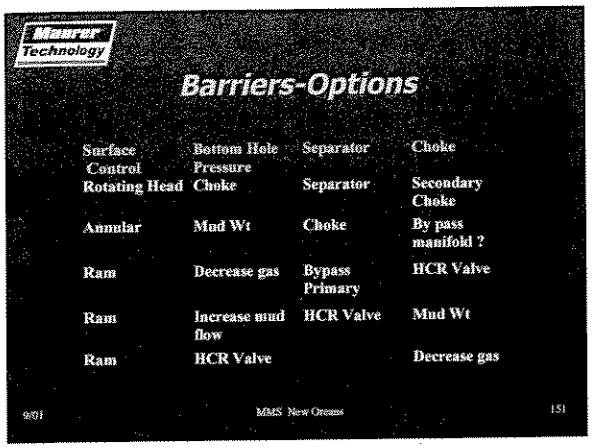

Maurer Technology
Input Pollution
OK
CANCEL
Theta (deg.)


Maurer Technology
Keep It Simple As Possible
• What is needed to operate the job
• Look at regulations
• Look at barriers
9/01
MMS New Orleans
147


Maurer Technology
END
9/01
MMS New Orleans
148


Maurer Technology
UB Drilling
Barriers
9/01
MMS New Orleans
149


Maurer Technology
Barriers
• BARRIERS are a planning and training guide to problems.
• The mud column as it exists in drilling and trips is no longer the primary barrier.
• What happens if ?
9/01
MMS New Orleans
150


Maurer Technology
Barriers-Options
Surface Control
Bottom Hole Pressure
Separator
Choke
Rotating Head
Choke
Separator
Secondary Choke
Annular
Mud Wt
Choke
By pass manifold ?
Ram
Decrease gas
Bypass Primary
HCR Valve
Ram
Increase mud flow
HCR Valve
Mud Wt
Ram
HCR Valve
Decrease gas
9/01
MMS New Orleans
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