MI SWACO

Customer-focused, solutions-driven

bp Macondo MC252 #1 GOMX

Drilling Fluids Program

"Macondo Prospect"
OCS-G 32306 #1
Mississippi Canyon 252
Deepwater Horizon

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	(Approve if program is consistent with BP Drilling Fluids guidelines and M-I PFM guidelines, and that any deviations are clearly stated and are technically sound, Criteria for review assigned to the drilling fluids program)		

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EXECUTIVE SUMMARY

Performance Fluids Management (PFM) will be an important key in the success of the **OCS-G 32306 #001** well at **Mississippi Canyon, Block 252.** Optimizing drilling performance, minimizing drilling fluids waste, and providing a system to minimize discharges/waste generation will be areas where proper fluid practices will contribute to the success of the project.

- **M-I SWACO** commits to providing BP with a complete PFM Drilling Fluid and Waste Minimization plan to establish a system of monitoring and controlling volumes of: overboard discharge for final disposal of cuttings and fluids associated waste.
- **M-I SWACO** commits to align procedures according with Best Management Practices Regarding Discharges Associated with Synthetic-Based Drilling fluids and/or Waste Minimization Best Practices.
- **M-I SWACO** will provide a PFM well site coordinator that will be committed to the execution as well as the final evaluation of the project. At the end of this project, the team will review lessons learned and create a plan for continual improvement for the following projects.
- **M-I SWACO** will utilize the concept of Integrated Fluids Engineering and Performance fluids management service lines into a single fluid and Waste minimization system to bring best practices and performances under a single coordinated framework.

KEY POINTS IN THE PERFORMANCE FLUIDS MANAGEMENT/PFM PROPOSAL

- A single fluids management approach to establish a performance base line in drilling fluids and waste minimization procedures for an operation encompassing BP's H.S.E. expectations, Best Management Practices and Environmental Management System.
- The design of a drilling fluids, solids control and waste handling program to:
  - Outline practices, guidelines, and recommendations to provide the highest quality drilling fluid for the project.
  - Prevent and minimize fluid losses by using the best procedures indicated in mud program and tools available such a Virtual Hydraulics.
  - Suggest and standardize optimum drilling practices for well bore cleaning, mud rheology, short trips, ROP limits, reaming and back reaming, and minimum circulating time.
  - Solids Control and Waste Handling evaluation and optimization in order to balance drilling fluid quality, material/equipment consumption and the volume/quality of solids control equipment discharges. Solids control recommendations in this program are based on the current rig equipment inventory and specific project expectations.

CRITICAL ANALYSIS

HEALTH, SAFETY, AND ENVIRONMENTAL (H.S.E.) CRITICAL ANALYSIS

Item	Critical Points	Action
1	**M-I SWACO HSE Management System STOP Program**	• Implementing BP internal programs and M-I SWACO HSE Management System • M-I SWACO HSE Passport • Daily Safety Meetings • START Program Implementing START cards • Records & Analysis • Lock-Out-Tag-Out procedures to be followed as necessary
2	**Job Safety Analysis and Permit to Work**	• Training and implementation. • Daily Safety Meeting and pre-operations Risk Analysis • Records & Analysis

DRILLING FLUIDS CRITICAL ANALYSIS:

Item	Critical Points	Action
1	Mud Losses	• Higher than normal Oil-on-Cuttings numbers were seen when using large amounts of LCM to treat for seepage losses. While the treatments of LCM appear to minimize seepage losses, it does increase the amount of mud lost on cuttings over the shakers and will necessitate the addition of wetting agents and emulsifiers to account for the solids added. Optimize procedures to improve shakers efficiencies and screens mesh designs and, use of pressure guns to minimize surface mud losses. • Managing losses according to lost circulation best practices (Lost Circulation Decision Tree and Particle Size Analysis) and coordinating with rig personnel for the required actions. See appendix 1 of Mud Program • Seepage losses have been managed by additions of Calcium carbonate (M, C) and G-Seal Plus. • VINSEAL additions in conjunction with Calcium carbonate and G-Seal Plus adds additional fluid loss control to formation. • The use of ECOTROL RD (fluid loss additive) to treat the HTHP fluid loss in the ***production zones*** will bring the fluid loss to < 1.0 cc @250 deg F. This is one way to try to minimize the fluid invasion that could contribute to fluid contamination in the MDT sampling runs.
2	ECD Control Practices and Well bore Cleaning	• M-I SWACO's Virtual Hydraulics must be used for planning purposes giving an "operating window" for the drillers on the rig. Actual PWD data is used in conjunction with this model to manage ECDs and well bore cleaning parameters. • Well bore cleaning should be looked at in the operational procedures and evaluated to minimize cuttings beds formations. • Use centrifuge to process recovered mud from the dryer. • Effective drilling practices plan for flow rate, rotation, connections, ROP, monitor trends, critical mud properties, high-density pills, LCM pills, wiper trips, and well control. Circulate the proper amount of time before connections to prevent cuttings from settling around the stabilizers.(see mud program Cutter size would have to be reduced further to decrease cuttings size and reduce the time needed to circulate prior to connections. • Higher emphasis on low end rheology v/s yield point. • High density sweeps instead of High viscosity pills proved to be more affective with no noticeable increase of ECD and no effect on rheological properties in deviated well bore sections. In straight well bore sections, recommend use of viscous sweeps. • Mud from the riser is cold and viscous, leading to increase initial pump pressures when starting to circulate. When running casing, it is shown beneficial to close the BOPs until the string gets to the mud line. Circulating the riser prior to opening the BOPs to run casing through should also help running ECD's. • Reduce Mud rheology to create minimum ECD, while running and cementing casing should be done in the last trip out of the well bore. Help to establish safe casing running procedures by Utilizing Virtual Hydraulics to predict surge and swab pressures. Monitor PWD values against Virtual Hydraulics during normal operations.

Solids Control Equipment / Waste Handling & Volumes Minimization Critical Analysis:

Item	Critical Points	Action & Contingencies
1	**Rig – Up Operations** (System already in place on the rig)	• Hot work permits required prior to commencement of work each day • Ongoing access to use of Crane for placing equipment • Systems will be tested prior to de-mobing last welders • All Personnel will adhere to Lock-Out-Tag-Out procedures when necessary. See Appendix 9 for procedures.
3	**NPT time due to equipment failure.** VERTI-G 03 Failure can occur due to the following items: • Motor failure • Belt failure on scroll • Hydraulic fluid leaks	**Preventative measures:** • Maintain adequate spare parts inventory on board for quick repairs • **Limit feed to 45 tons per hour** **If failure occurs the following actions will be taken:** • If necessary complete JSA for work to be done. Follow Energy Isolation certificate in Appnedix 9 for Lock-Out-Tag-Out. • Record depth and time failure occurred and contact PFM coordinator immediately to acquire composite of shaker cuttings and perform cuttings retention test on sample • Repair and restart unit • Record depth and time unit is back on line and processing and calculate total mud lost on cuttings to be incorporated into daily weighted average
4	**NPT time due to equipment failure** **Centrifuge failure:** If used to process recovered fluid from the dryer	**Preventative measures:** • Maintain adequate spare parts inventory to ensure speedy repairs • M-I SWACO personnel will be responsible for daily maintenance routines to be performed and recorded on daily reports for review
5	**Centrifuge failure due to the following items:** • Bearing failure • Feed pump failure • Drive belt failure • Pack off	• Monitor feed rates and densities to make adjustments when necessary **If failure occurs the following actions will be taken:** • If necessary complete JSA for work to be done. Follow Energy Isolation certificate in Appnedix 9 for Lock-Out-Tag-Out. • Route fluid from the dryer direct to mud system • Make necessary repairs to get centrifuge back on line • Clean and restart unit The roles and responsibilities for all personnel associated with the PFM effort on this project are listed on the following pages
6	**Optimization of Shale Shakers and** **Proper Screen Maintenance**	• Coordinate and suggest requirements for the optimum equipment performance • Do Not use 40 mesh screens on Scalping shakers. Use 20 mesh with the 40 mesh on the Secondary shakers if necessary • Coordinate and suggest best practices for screen storage, installation, and evaluation of shale shaker components • Pre-planning for screen change for bottoms up after tripping • Records & Analysis • Innovations: Optimize screen configuration for lower overall R.O.C.
7	**Waste Disposal Volumes**	• Optimize solids control equipment efficiency LGS removal processes • Identify mud quality reclaimed by the vacuum system to determine if DF will be returned to system or sent in for disposal
8	**High Solids and Fluid Waste Generation**	• Identify waste's main sources, and coordinate and control by suggesting and implementing optimization procedures • Monitoring Waste generation Volumes and cost associated for treatment, storage and disposal

MODEL, BENCHMARKS AND GOALS

H.S.E. BENCHMARKS AND GOALS:

Item	Benchmark	Goal
Lost Time Accidents	0	0
Days Away From Work	0	0
Spills	0	0
Total Man Hours Worked	To be Tracked	To be Tracked

DRILLING PROJECT PERFORMANCE BENCHMARKS AND GOALS:

Item	Benchmark P-50	P-10 Goal
% NPT of the drilling operation (Defined as Non Productive time Days of the drilling operation divided to the entire drilling operation in days until start /completion)*100%	BP and PFM engineer will track Non Productive Time associated to the whole drilling operations in order to relate these numbers with PFM NPT	< 10 % *to be validated by BP.
NPC of the drilling operation (Defined as Non Productive Cost of the entire drilling operation divided by the total drilling cost until completion)*100%	BP and PFM engineer will track Non Productive Cost associated to the whole drilling operations in order to relate these numbers with PFM NPC	< 10 % * to be validated by BP

TOTAL PFM BENCHMARKS AND GOALS

Item	Benchmark P-50	P-10 Goal
NPT due to PFM (Defined as Non Productive time associated to PFM / Total Non Productive Time of the entire operation until completion)	4 – 10 % *	< 5 % of total NPT of operation
NPC due to PFM (Defined as Non Productive Cost associated to PFM / Total Non Productive Cost of the entire operation until completion)	BP and PFM engineer will track Non Productive Time associated to PFM events and estimate the cost in order to set these numbers as benchmarks.	< 5 % of total NPC cost of operation

- **Between 5 to 10 % is the Normal % NPT of Historical data from overseas operations. PFM personnel will record Non- Productive Time associated to PFM events and estimate the cost in order to set these numbers as benchmarks.**

DRILLING FLUIDS BENCHMARKS AND GOALS

Item	Benchmark P-50	Goal
NPT due to Drilling Fluids Defined as: (Non Productive time associated to Drilling fluids/ Total Non Productive Time of the entire operation)*100%	4-10 % *	< 5 % of total NPT time of operation
NPC due to drilling Fluids (Defined as: (Non Productive Cost associated to PFM / Total Non Productive Cost of the entire operation)	BP and PFM will track Non Productive Time associated to PFM events and estimate the cost in order to set these numbers as benchmarks.	< 5 % of total NPC of operation

* Between 5 to 10 % is the Normal % NPT of Historical data from overseas operations even though were not found NPT and associated cost in records. MI will record Non Productive Time associated to Drilling fluids events and estimate the cost in order to set these numbers as benchmarks.

SOLIDS CONTROL AND WASTE MANAGEMENT GOALS

SOLIDS CONTROL:

Item	Benchmark	Goal
NPT due to Solids Control equipment (Defined as Non Productive time associated to Solids Control equipment / Total Non Productive Time of the entire operation)	0	0
NPC due to Solids Control equipment (Defined as Non Productive Cost associated to Solids Control equipment / Total Non Productive Cost of the entire operation)	0	0
Total Solids Control Equip & Personnel Cost v/s drilled ft	*To be tracked* **	*To be tracked* **
Screens Usage per day **	Screen consumption will be tracked.	Screen consumption will be tracked.

Note: Non Productive Time associated to Solids control equipment should be taken in account only when drilling down time is due to solids control equipment failures. Solids Control equipment failures, which do not affect drilling, will be captured as % of down time.

WASTE HANDLING:

Item	Unit	Benchmark	Goal
Total Waste Handling *	Cost v/s drilled ft	To be tracked	To be tracked
Oil content on discharged cuttings* (Average for daily composite sample as per latest EPA suggestions, June 4, 2001.)	Average of % Oil by weight	< 6.9 %	< 6.9 %
Bbls mud to Bbls cuttings discharged Average for daily composite sample		To be measured	To be measured
Total SBM Cuttings Discharges	Average Bbl / ft drilled	.28	.28
Total SBM Mud Discharges**	Well Average Bbl / ft drilled	.10	.09

* The model did not included much data regarding solids control, boat and rig cleaning, and the different items involved with Performance fluids management. Accurate data will be recorded for this well in order to update the model

EMS MUD CUTTINGS AND MUD TARGET GOALS (BBLS)

Performance Benchmark	16.5x20" Section	14.75x16.5" Section	*12.25x14.5" Section	10.625x12.25" OH Section
Section Length	3517	2,800'	1700	2650
Cuttings Discharges	1366	740	347	386
Mud Discharges	68	37	17	19
Mud + Cuttings Discharges	1434	777	364	405

EMS MUD CUTTINGS AND MUD TARGET GOALS (BBLS/FT)

Performance Benchmark	16.5x20" Section	14.75x16.5" Section	*12.25x14.5" Section	10.625x12.25" Section
Section Length	3517	2800	1700	2650
Cuttings Discharges	.38	.26	.20	.14
Mud Discharges	.04	.04	.05	.04
Mud + Cuttings Discharges	.42	.3	.25	.18

*Contingency

GWSI Fluid Network Objectives and Weighting

(APPROVED BY WELLS TEAM)

	Objective	Weighting
1	Basis of design complete/updated with options/risk assessment and recommended technical solutions.	10%
2	No stuck pipe due to either well bore cleaning or instability problems.	10%
3	Consequential NPT less than 7.5% of drilling NPT from DIMS.	10%
4	Drilling performance - No barite sag resulting in NPT.	10%
5	Drilling performance –Fluid losses to the formation to be ≤ 2,250 bbls	10%
6	Drilling performance - Produce stable and clean well bore for the specified intervals. Measured by the ability to run casing to section depth first time and within planned time for the running of the casing.	10%
7	Drilling performance - LCM strategy in place, no NPT due to failure of the strategy.	10%
8	Environmental - 100% NPDES regulatory requirements to be met. (USA GOM only).	10%
9	No LTIs.	10%
10	PFM actual cost within 10% of P-50 planned cost.	10%

SUMMARY OF WELL COSTS:

[redacted]

[redacted]

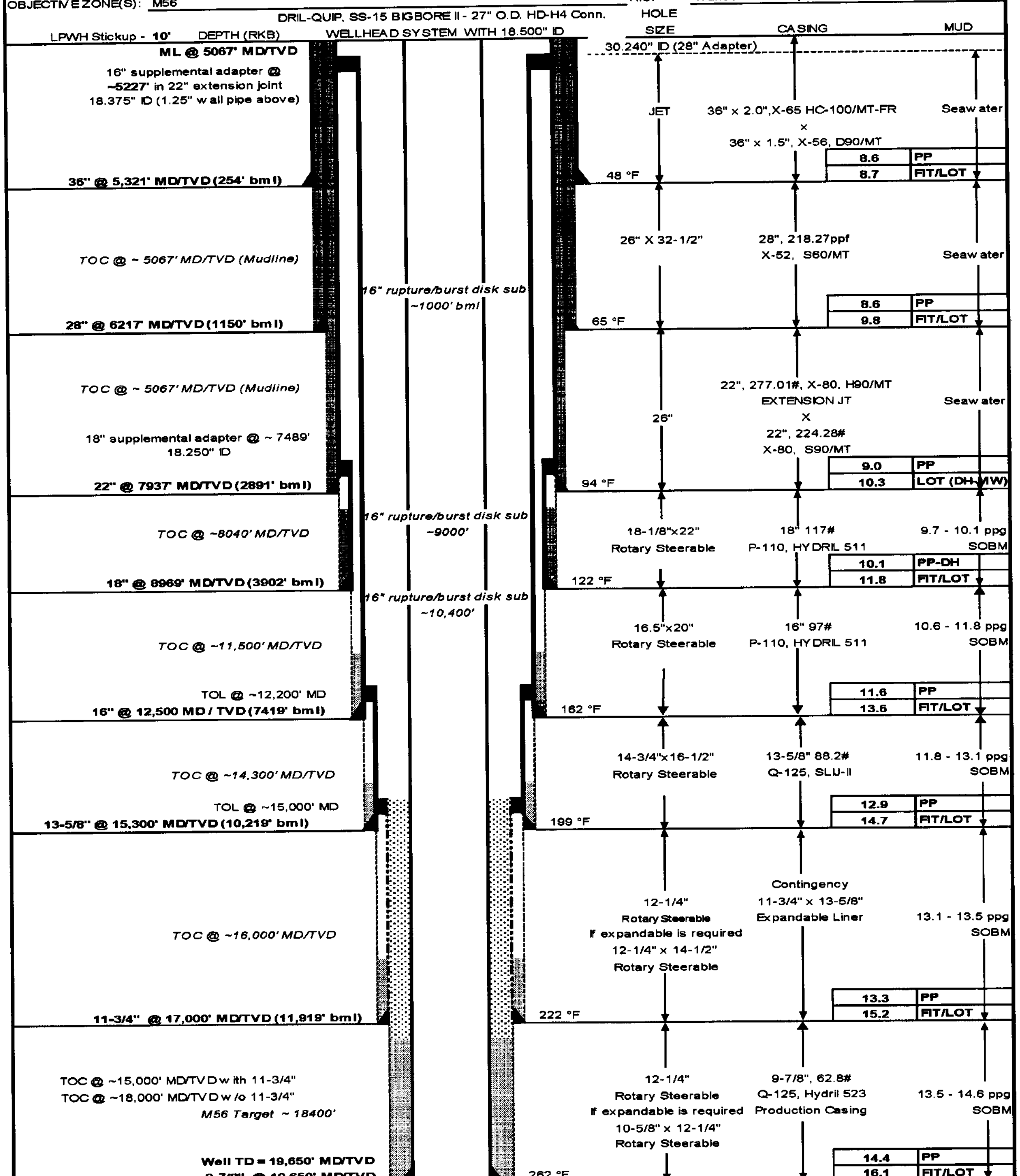
[redacted]

WELLBORE SCHEMATIC:

BP GoM Deepwater Exploration

Macondo Prospect (Basis of Design)

OPERATOR:	BP PARTNER: TBD	DATE:	1/6/2010_Rev 13.1
WELL NAME:	MC 252 #1, MACONDO PROSPECT, OCS-G-32306	PTD:	19,650' MD/TVD
FIELD / PROSPECT:	WILDCAT AREA: OFFSHORE STATE LA	RF ELEV:	75' (Horizon) WD: 4992'
SURFACE LOCATION:	X=1,202,803.88 Y=10,431,617.00	PBHL:	X=1,202,803.88 Y=10,431,617.00
OBJECTIVE ZONE(S):	M56	RIG:	Transocean Deepwater Horizon



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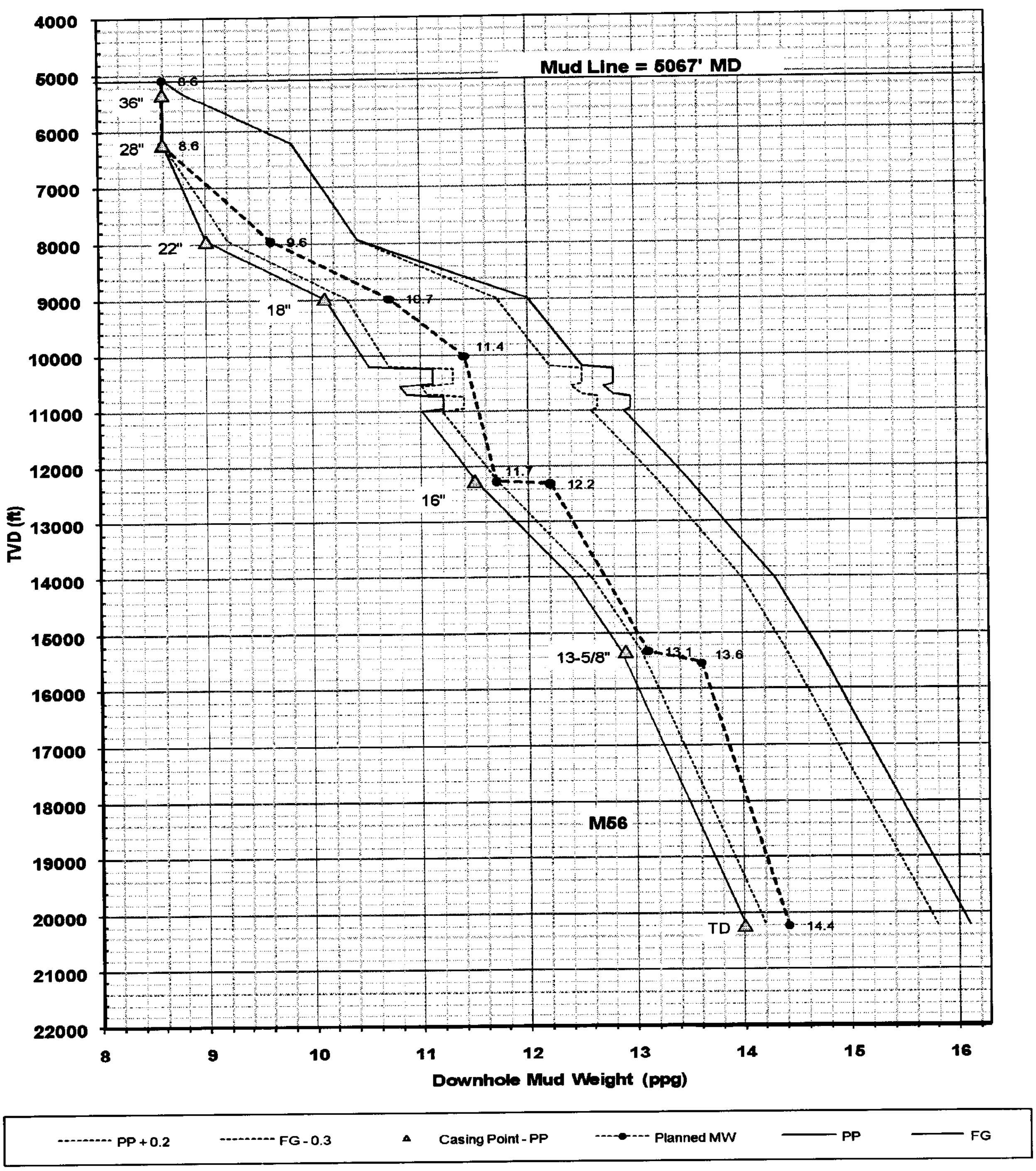
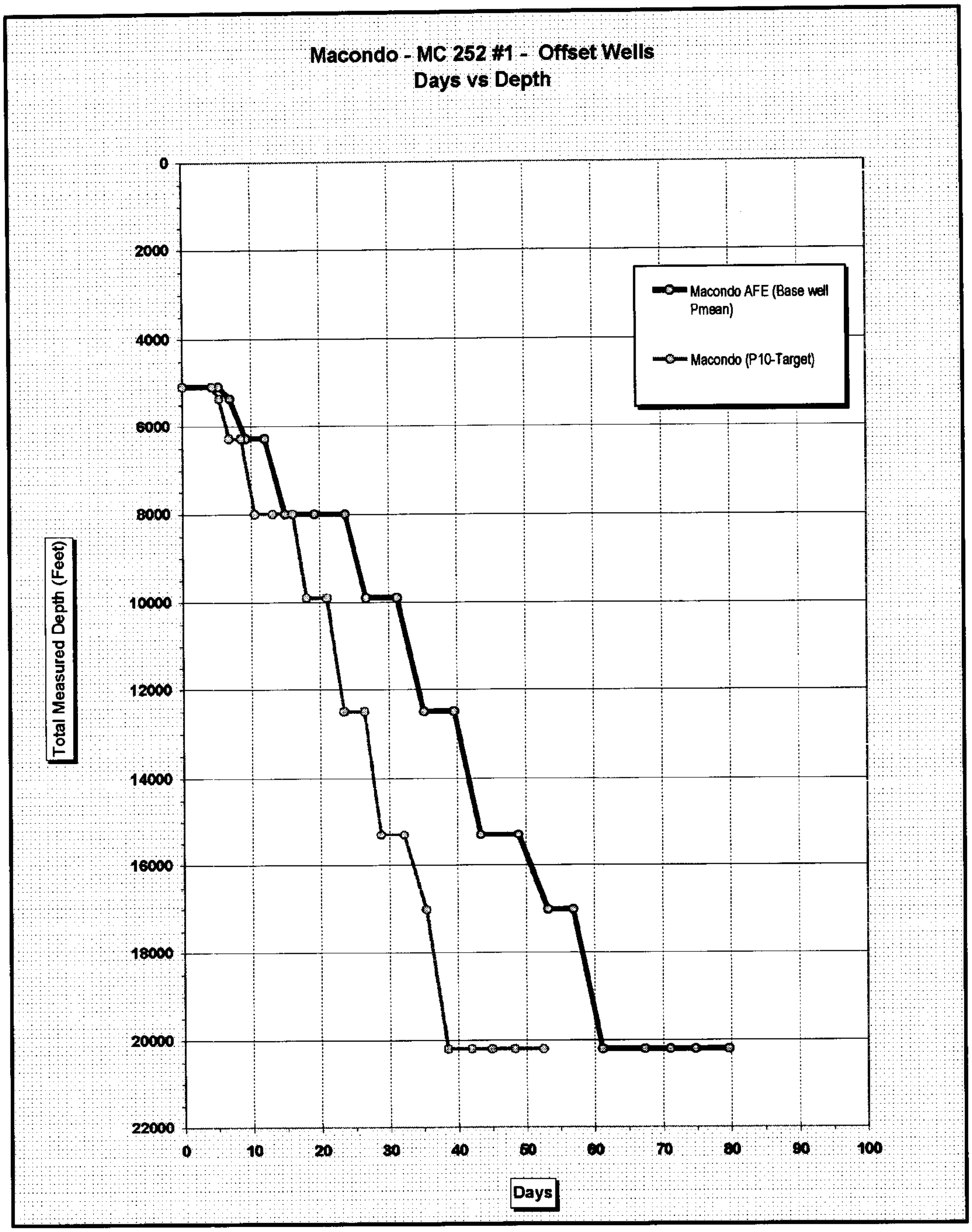
PORE PRESSURE PREDICTIONS:

MC 252 #1 - Macondo Prospect



DAYS VS DEPTH MEAN:



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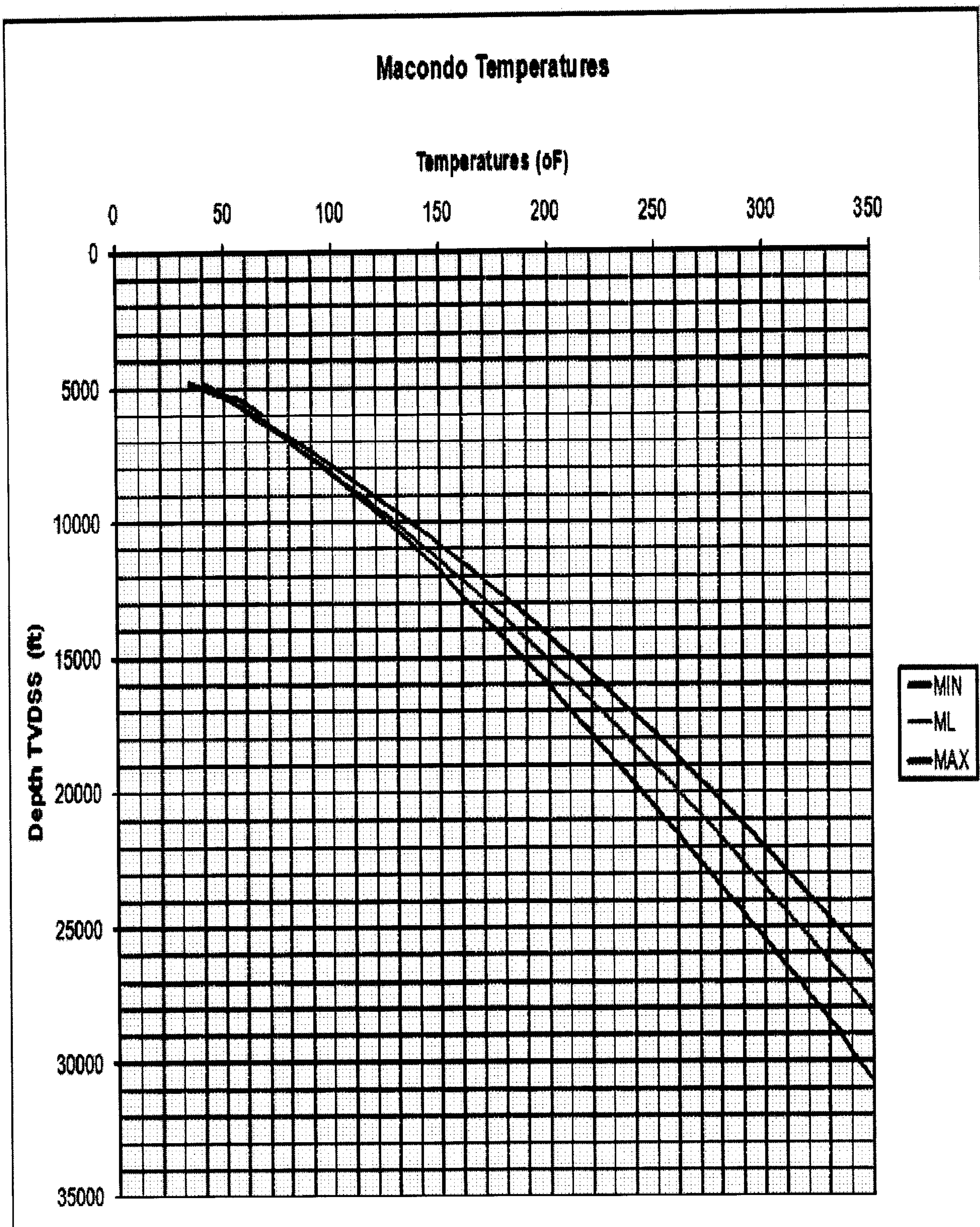


RHELIANT™ SYSTEM COMPONENTS:

Suremul – is a blend of liquid emulsifiers, wetting agents, gellants, and fluid stabilizing agents. It is used as the primary emulsifier in this system. **Suremul** reacts with lime to form calcium soaps. This calcium soap acts as the emulsifier in this tightly emulsified conventional low filtrate system. **Suremul** along with **Surewet** forms an extremely tight emulsion and is stable at high temperatures. The recommended concentration is 7.0 – 8.0 ppb.

Surewet – functions as wetting agent in the **Rheliant** system. It also serves as a secondary emulsifier. Preferentially synthetic wets weight material and drill solids to minimize water-wet solids. It also improves thermal stability, rheological stability, filtration control, emulsion stability, and the fluids resistance to contamination. Additionally, it is used to aid in the reduction of synthetic base fluid retained on cuttings.

Rheflat – functions as a rheological modifier. The flat rheology profile is generated using this rheology modifier. This polymer can enhance low-end rheology and yield point by interacting with fine solids such as organo clay and low gravity solids. The interaction is temperature stimulated in such a way that the low-end rheology enhancement is greater at high temperatures and weaker at low temperatures. This enhancement in low-end rheology and YP can be affected by the amount of organo clay and fine low gravity solids in the system. A larger amount of organo clays or fine low gravity solids tends to cause a greater increase in these properties and a flatter profile. Treatment of **Rheflat** to active drilling fluid will have more impact on the low-end rheology at high temperatures than on the low temperature rheology. No significant increases in viscosity will be seen if the system contains optimal amounts of drill solids and organo clay.

Rhethick – Polyamide based viscosifier and rheology modifier. Used to provide overall viscosity and to improve sag control of the flat rheology system when necessary. This viscosifier is chemically different from **Rheflat** and reacts differently with solids. Pilot testing is recommended before addition. Recommended concentration is 0.25 – 1.25 ppb.

Rheduce – Thinner that can be used to reduce the overall viscosity of the system without significantly changing the flat rheology profile. Because of its potency **Rheduce** should be pilot tested before additions are made. 0.1 – 0.2 ppb is a good starting point.

VG Supreme – This organo clay is used at minimum concentration to provide body and viscosity for proper barite suspension. Typically, one to two pounds per barrel should be sufficient for the initial mix of the system. This organo clay is specially designed for high temperature applications. One part **VG Supreme** may be mixed with 2 parts **VG Plus** for lower temperature applications.

RHELIANT™ SYSTEM COMPONENTS:

Ecotrol – filtration control additive for use in synthetic based mud systems. It is specially designed to provide tight high temperature high-pressure fluid loss control at low concentrations. Stable at high temperatures.

Calcium Chloride – salt is used to reduce the activity (Aw) of the mud for shale inhibition.

- **Lime** – is used in all synthetic base muds for alkalinity control to increase the P_{SM} and maintain excess lime. In this IO1618 system it is used at a high concentration as a source of calcium for forming calcium soaps with the primary emulsifier. It is used in all synthetic base systems as a source of alkalinity when drilling acid gases (H_2S, CO_2).
- It is difficult to specify exact ranges for mud properties such as plastic viscosity, yield point, and gel strengths due to the many variables affecting the value of these properties including the synthetic base fluid properties, the type, size and concentration of solids, the brine concentration, and the overall stability of the emulsion. The recommended properties are useful as a guide to the final desired fluid parameters. Any significant deviations from these parameters should be noted and brought to the attention of bp and M-I's engineering staff in conjunction with the drilling supervisor on location.
- Plastic Viscosity should be maintained at minimum values to optimize bit hydraulics and penetration rates. If the Plastic Viscosity trends upward over a period of time without increases in fluid density, it usually indicates that fine solids are building up in the mud. Increases in the volume percent solids even from weight material will increase the plastic viscosity. Decreases in the Synthetic Water Ratio (higher water content) will also increase the Plastic Viscosity.
- Yield Point and gel strengths are governed by two requirements. The first is the need to maintain sufficient thixotrophy to suspend weight material and cuttings, plus provide carrying capacity. The second requirement is to minimize annular pressure losses and Equivalent Circulating Densities (ECD's). The yield point and gel strengths can be increased with additions of **Rhethick**. To increase viscosity for sweeps use **Rhethick**. These properties can be reduced ordinarily with additions of Synthetic Base Oil or **Rheduce**. Pilot testing should be performed before any additions of **Rheduce**.

RHELIANT™ SYSTEM COMPONENTS:

- The allowable low gravity solids content depends upon the Synthetic water ratio, water phase density, and the volume and specific gravity of the solids themselves, assumed to be 2.4. Maintain rigorous control of the low gravity solids concentration. Solids increase cake thickness, plastic viscosity, pressure losses, and the need for chemical treatments and the likelihood of water wetting the solids. The low gravity solids should be kept as low as economically possible with the available solids control equipment and dilution, if necessary. Calcium Carbonate with a SG of 2.7 added to the system will also show up as a low gravity solid. This concentration should be backed out to determine the actual amount of low gravity solids derived from drill solids.
- Maintain alkalinity (P_{SM}) at programmed specifications (1.0-3.0 ml 0.1N H_2SO_4) at all times to ensure adequate excess lime is available in the system to form the required calcium soaps with the primary emulsifier and to react with carbonate gases. This may require large amounts of Lime if carbon dioxide or H_2S gas contamination is encountered. Be prepared and treat accordingly.
- Maintain Electrical Stability in excess of 300 to 600 volts. Record temperature at which the reading was taken. Electrical Stability is an important indication of emulsion stability but is should not be used as an absolute value or indication of its condition. A mud with a high but declining electrical stability may not be as stable as a mud with a lower but stable electrical stability. Muds with electrical stability problems will have rheological and filtrate indications as well as low and declining electrical stability values. Low electrical stability values may be a cause for concern however; an established trend of declining values is more serious and requires immediate attention.
- Calcium Chloride concentration should be tested by titration and maintained at 18-22% by weight or 200 to 225K Chlorides Water Phase. A lesser value could result in diminished cuttings integrity depending upon shale versus mud activity (A_w). Conversely, do not allow concentrations of Calcium Chloride to exceed 38% by weight as the near saturation level of the brine can cause fluid instability, in particular salt crystallization, which can produce water wet solids and require large amounts of wetting agent to correct. There is noe need to add Calcium chloride while drilling through salt. Concentration will rise as the salt is penetrated and drilled. After exiting salt, let the chloride % drift drift down and then begin additions to maintain at recommended 18-22% range.
- Condition mud before cementing according to cementing program.

Depth Interval	*8,969' – 12,500' MD/TVD -16½ x 20"*
Drilling Fluid System	RHELIANT™
Key Products	*M-I BAR, SUREMUL, SUREWET, ECOTROL, RHETHIK, RHEFLAT, RHEDUCE, RHEBUILD,* VG-PLUS / SUPR, $CaCl_2$, Lime, $CaCO_3$ & G-SEAL
Solids Control	**2 x Scalping Shakers, 4 x Linear Motion Shakers (165 mesh screens), 2 Hi G Mud Cleaners, M-I SWACO auger, dryer and centrifuge**
Potential Problems	**Pit management** - Displacement program below to minimize interface. Incorporation of ≅ 900 bbls ENCORE fluid into the **RHELIANT™** system. Maintaining stable mud weight while drilling cement shoe track.

INTERVAL DRILLING FLUID PROPERTIES	
Mud Weight (ppg):	**10.6 – 11.8**
Plastic Viscosity (cps):	**14 – 18**
Yield Point (lbs/100ft²):	**22 – 27**
Gels (lbs/100ft²): (10S/10M)	**19 – 20/30 - 32**
3/6 RPM (Fann Units):	**15/14 – 17/18**
HTHP Fluid Loss (ml/30min):	**< 4.0 ml @ 250 degrees**
P_{SM} (ml .02N H_2SO_4):	**1.0 – 3.0**
Chlorides Whole Mud (mg/l):	**35K – 40K**
Salt (% by wt):	**18 – 22%**
Lime (ppb):	**1.0 – 2.0**
Electrical Stability (volts):	**> 400**
Synthetic/Water Ratio:	**70/30**
Maximum LGS Permitted (%):	**< 8.0% due to background LCM**
Check rheology at 150°F/100°F/40°F (API specifications). Run HTHP at 250°F, 500 psi	

INTERVAL OBJECTIVES:

The 16½X20" well bore will be drilled to a setting depth (16" casing) of 12,500'. This section will be drilled with **RHELIANT™** SBM. The first plug @ 5,881'will be drilled with **RHELIANT™** SBM while displacing seawater left in well bore above plug and the riser volume. Once the shoe track is tagged, the Haliburton ENCORE system will be displaced with **RHELIANT™** SBM while drilling the cement shoe track. The ENCORE system will be incorporated into the **RHELIANT™** system. The compatibility of the fuids should not become an issue as they ar both IO systems. There may be necessary circulating time to treat the system in case there are any issues with the system. The ENCORE system is a GEL free system and some GEL is used in the **RHELIANT™**. The expected LOT test for this interval is 12.0 ppg.

INTERVAL DISCUSSION AND PROCEDURES:

- It will take approximately 1821 bbls to fill up the riser, 250 bbls for CKB lines, 2000 bbls active circulating system, and 1500 bbls additional volume to begin the interval. We rcccommend ordering <u>***5500***</u> bbls 10.6 ppg **RHELIANT™** synthetic base mud to start operations. The volume can be changed as determined by well site leaders and fluid specialists on location. The last Haliburton drilling fluid report states the ENCORE system was displaced with seawater 1000′ below mud line before unlatching. The extra 1500 bbls may become necessary to replace the volume in 18″ casing that is not ENCORE (300 bbls).
- After riser is latched trip in well bore to cement plug at ≅ 5,581′. CKB lines can be displaced at this point. Do not overdisplace lines. Begin drilling cement plug and displaceing the seawater from well bore with **RHELIANT™**. Seawater can be discharged until fluid specialist determines to take returns of SOBM to pits. A detailed displacement procedure will be prepared by Fluid Specialists on location with strokes and utilization. This procedure will include pumping a hi-vis sweep in front of the SOBM to displace seawater.
- As the initial plug is drilled (@5,881′) circulate until water has been displaced from riser. Do not boost while displacing water until SOBM is well above stack. After plug is drilled and seawater is displaced, tih to bottom and tag cement shoe at ≅8,883′ and begin drilling cement shoe track. The riser can be boosted to help string out the ENCORE as it is being displaced to help mix the systems thouroughly. Maintain the mud weight at 10.6 ppg as the shoe track is being drilled and the 10.1 ppg ENCORE is circulated to surface. Mud weight can be maintained at surface (10.6 ppg) by dusting the system with barite as needed. Be prepared to treat system (Synthetic B, SUREMUL, RHETHIK, and SUREWET) on surface if there is any evidence of contamination from the ENCORE being blended with **RHELIANT™**. *NOTE: no cantamination is expected.*
- Drill shoe track plus 10′ of new well bore and obtain an acceptable FIT/LOT (12.0 ppg).
- Once drilling commences begin additions of LCM into system @15 – 17 ppb. Use Standard maintainence mix of Safecarb 40@15ppb, Safecard 250@15ppb, Calcium Carbonate 30/50@15ppb, and G-SEAL PLUS @15ppb totaling 60 ppb in pit. Bleed over into active to maintain 500 lbs/hr in system. We can adjust based on total concentration needed in system.
- Build the Emergemy LCM pill (200 bbls @84ppb) and have ready to pump if needed. Build with the following concentrations: G-SEAL PLUS @10ppb; Safecarb 40 @20ppb; Safecarb 250 @20ppb′ BLOCK R 750 @14 ppb; KWIKSEAL C @ 5ppb; KWIKSEAL M @5ppb; VINSAEL M @ 10 ppb.

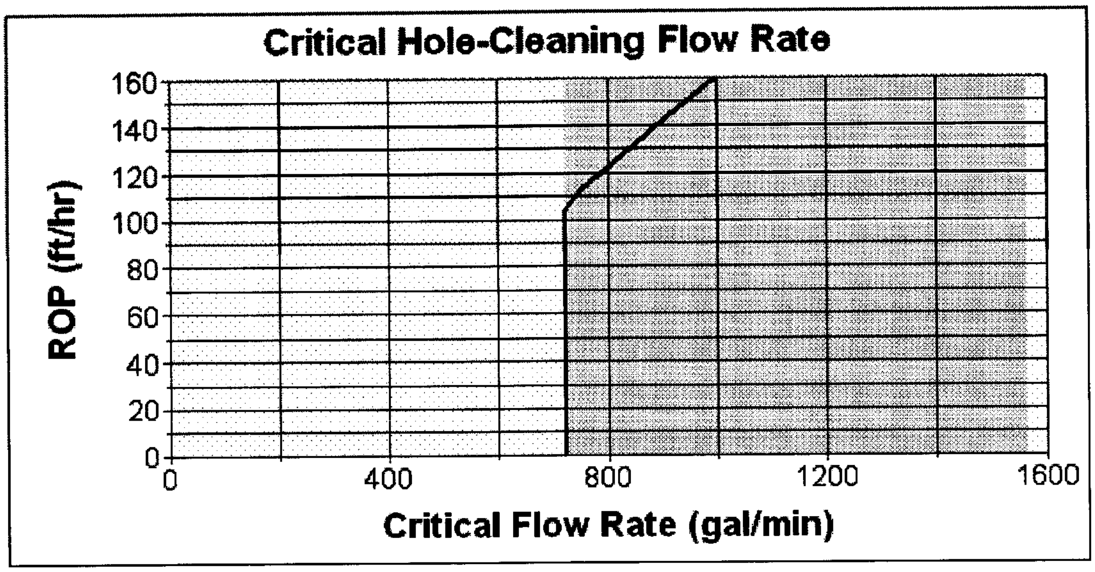
INTERVAL DISCUSSION AND PROCEDURES:

- Refer to Loss circulation guidelines / decision tree found in Appendix 1 of this program in the event losses are encountered.
- Severe losses may require pumping MI-SWACO's **Form-A-Squeeze, EZ-Squeeze, or Form-A-Set AK.** Refer to *FAS software* for formulation, mixing and pumping instructions. Mixing in structions can be found in Appendix 7 of this program
- Maintain enough Form-A-Squeeze LCM material on location to build and pump a 200 bbl pill. In the event of loss circulation this pill will be pumped after conventional LCM pills does not heal the formation. Maintain enough EZ-Squeeze material on loaction to build and pump a 200 bbl pill. This will be pumped after a Form-A-Squeeze pill has been pump and does not heal the formation to regain circulation. A technician will have to be flown to rig to mix this pill.
- Maintain enough Form-A-Set AK material on location to build and pump a 200 bbl pill if needed.
- Maintain "flat" characteristic of the system with small additions of "Rheflat" and "Rheduce" as determined by pilot testing. Maintain approximately equal 6 & 3 and YP across temperature spectrum. Pilot test to confirm appropriate additions and track concentrations in "OneTrax".
- Record rheology at 40 degrees, 100 degrees, and 150 degrees daily and submit on daily mud report in OneTrax.
- At TD pump a 100 bbl viscous sweep and circulate the well bore clean. One circulation is never enough. (See "Procedures – Sweep/Well bore Cleaning") Due to the possibility of large PDC cuttings collecting in the BOP cavities pump another 100 bbls high viscosity sweep at the well head before POOH. The "piston" effect of running the liner through casing may result in mud losses both running the liner and cementing. Ensure that sufficient mud volumes are aboard the rig to run and cement the liner in the event that losses occur. Run "SurgePro" to model running 16" casing.
- As per BP drilling engineer, 16.5 ppg pad mud will be spotted on bottom in rat hole prior to tripping out of well bore to run casing.
- Begin running PPT daily and report on Mud Report (500 PSI, 90 micron disk, 250°F or BHT if <250).
- Monitor the LCM concentrations with the **Wet Sieve Test**. The fluid specialist on ocation will complete test daily and adjust LCM additions based on the particle size distribution identified based on discussed LCM plan for interval. Testing procedures are included in the program (Appendix 5). Email results to Project Engineer daily.
- The Viscometer Sag Shoe Test (VSST) will be run daily and reported in comments section of Daily Mud Report.
- Should the need arise for additional wellbore cleaning; refer to Appendix 6 of this program.
- Refer to RHELIANT guidelines for chemical additions.

INTERVAL DISCUSSION AND PROCEDURES:

- Track losses in section recap:
  - Bbls lost while P/U and RIH with liner
  - Bbls lost while RIH with liner on landing string
  - Bbls lost while washing the liner to bottom (if required)
  - Bbls lost while circulating after liner landed
  - Bbls lost while pumping and displacing cement.
  - Bbls left behind pipe.

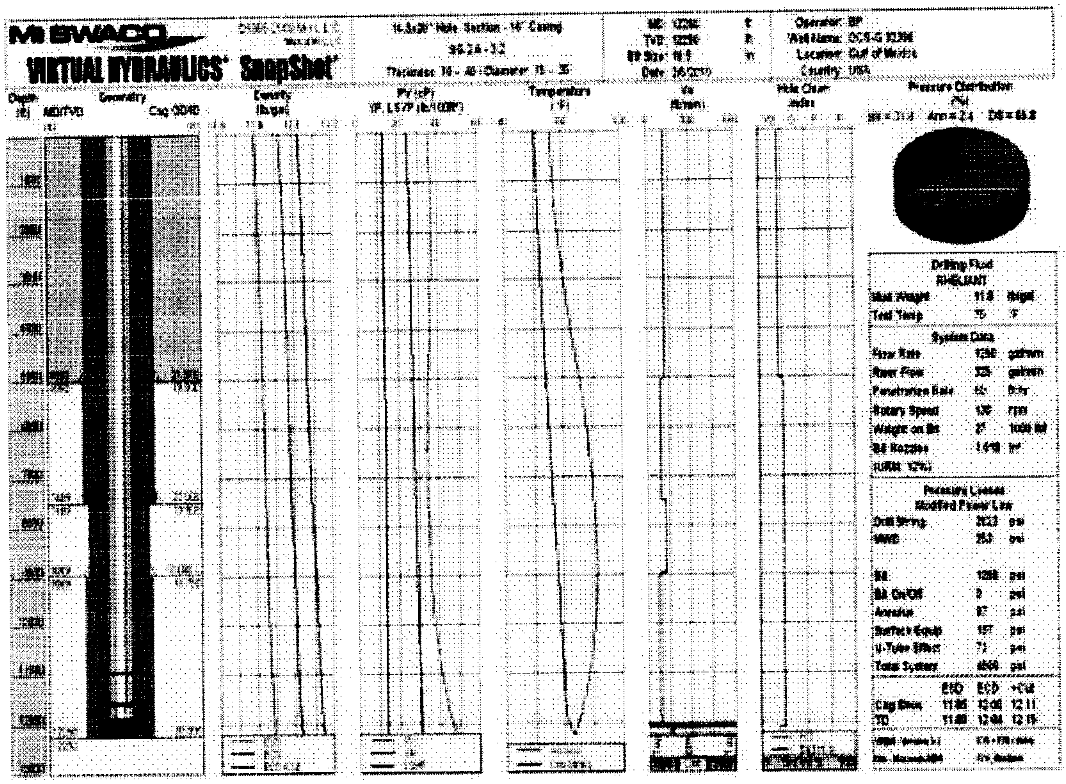
- **BP HOLE CLEANING MODEL:**

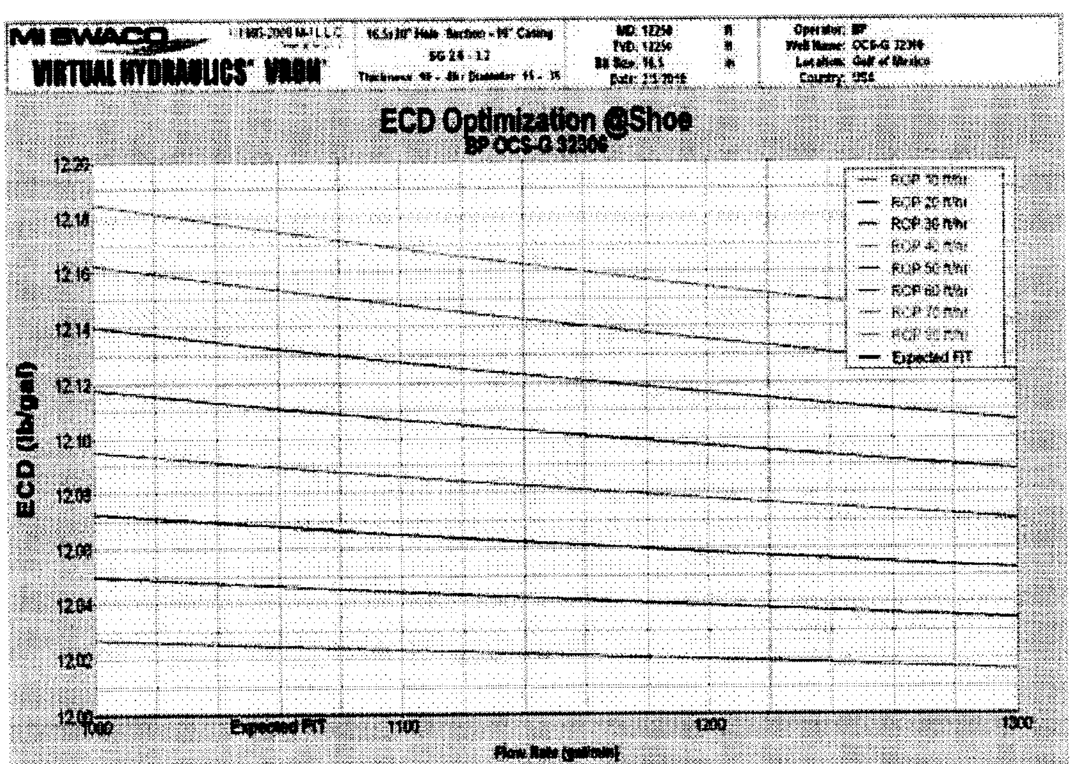


Drilling recommendations for this interval:

- Flow Rate: 1000 - 1300 gpm
- Riser Boost: 300 – 350 gpm
- Rotary RPM: 130 rpm; as drilling parameters allow.
- ROP: 20 ft/hr – 100 ft/hr; as well bore conditions dictate.

VIRTUAL HYDRAULICS:





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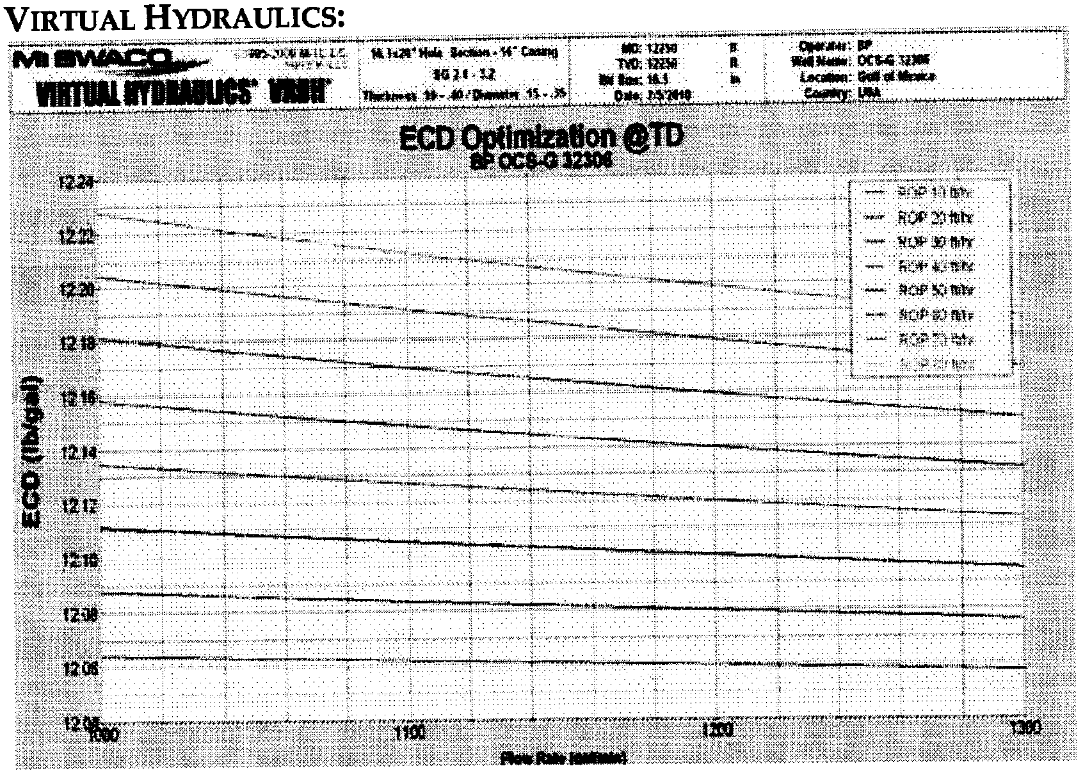
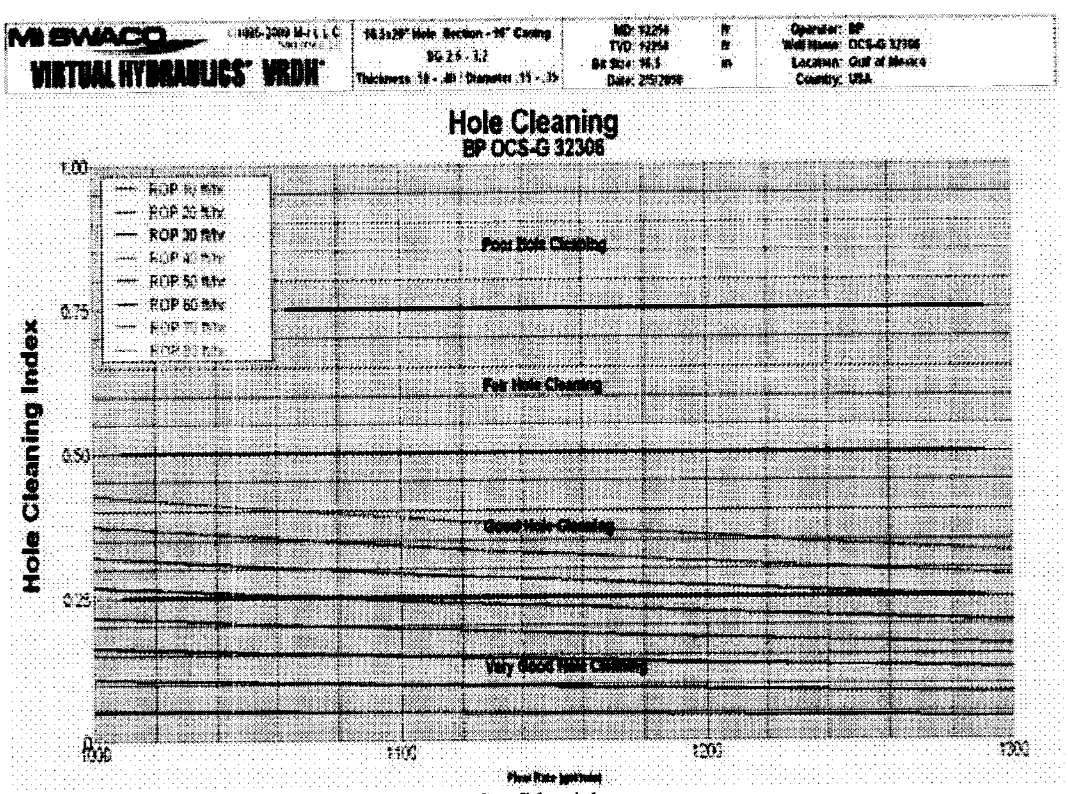
VIRTUAL HYDRAULICS:





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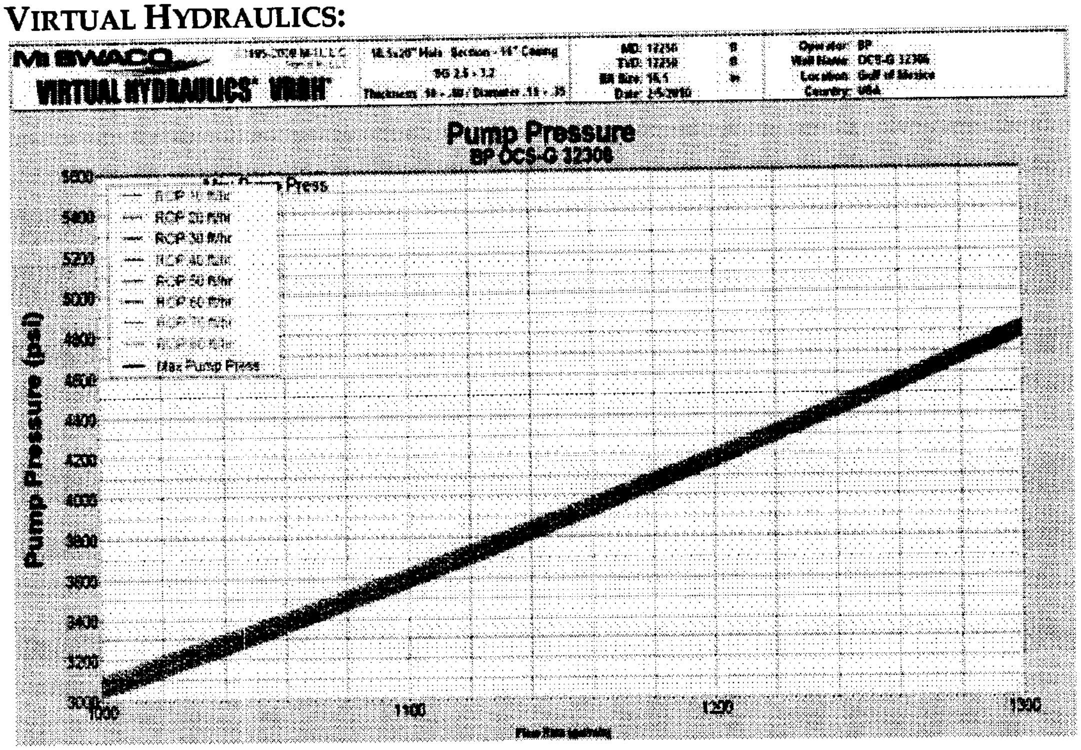


Depth Interval	*12,500' - 15,300' MD/TVD - 14¾ x 16½"*	
Drilling Fluid System	RHELIANT™	
Key Products	*M-I BAR, SUREMUL, SUREWET, ECOTROL, RHETHIK, RHEFLAT, RHEDUCE, RHEBUILD,* VG-PLUS / SUPR, $CaCl_2$, Lime, $CaCO_3$ & G-SEAL	
Solids Control	2 x Scalping Shakers, 4 x Linear Motion Shakers (165 mesh screens), 2 Hi G Mud Cleaners, M-I SWACO auger, dryer and centrifuge	
Potential Problems		
INTERVAL DRILLING FLUID PROPERTIES		
Mud Weight (ppg):		11.8 – 13.1 ppg
Plastic Viscosity (cps):		25 – 30
Yield Point (lbs/100ft²):		18 – 24
Gels (lbs/100ft²): (10S/10M		15 – 25/30 – 35
3/6 RPM (Fann Units):		12/11 – 16/15
HTHP Fluid Loss (ml/30min):		< 4.0 ml @ 250 degrees
P_{SM} (ml .02N H_2SO_4):		2.0 – 3.0
Chlorides Whole Mud (mg/l):		35K – 40K
Salt (% by wt):		18 – 22%
Lime (ppb):		1.0 – 2.0
Electrical Stability (volts):		> 400
Synthetic/Water Ratio:		73/27 – 75/25
Maximum LGS Permitted (%):		< 8.0% due to background LCM
Check rheology at 150°F/100°F/40°F (API specifications). Run HTHP at 250°F, 500 psi		

INTERVAL OBJECTIVES:

The 14¾ x 16½" well bore will be drilled to a setting depth (13⅝" liner) of 15,300'. This section will be drilled with **RHELIANT™** SBM. Drill section without losses to formation. Maintain background LCM while drilling interval.

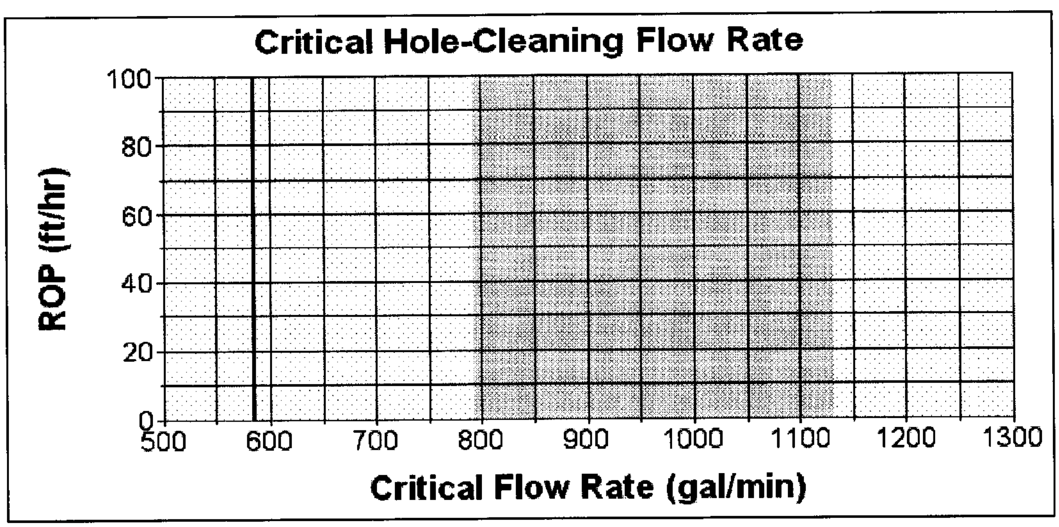
INTERVAL DISCUSSION AND PROCEDURES:

- Rheliant drilling fluids engineering will be substantially the same as in the previous interval.
- Drill shoe track plus 10' of new well bore and obtain an acceptable FIT/LOT (13.6 ppg) to drill ahead to section TD. Perform FIT/LOT with the interval ending mud weight.
- Maintain "flat" characteristic of the system with small additions of "Rheflat" and "Rheduce". Approximately equal 6 & 3, YP across temperature spectrum. Pilot test to confirm appropriate additions and track concentrations in "OneTrax".
- Maintain additions of LCM into system @15 – 17 ppb. Use Standard maintainence mix of Safecarb 250@15ppb, Calcium Carbonate 30/50@15ppb, and G-SEAL PLUS @15ppb totaling 60 ppb in pit. Bleed over into active to maintain 500 lbs/hr in system. We can adjust based on total concentration needed in system. Discontinue use of Safecarb 40 in LCM pit. The system will have enough fines to cover this mocron size.
- Maintain the Emergemy LCM pill (200 bbls @84ppb) and have ready to pump if needed. Build with the following concentrations: G-SEAL PLUS @10ppb; Safecarb 40 @20ppb; Safecarb 250 @20ppb' BLOCK R 750 @14 ppb; KWIKSEAL C @ 5ppb; KWIKSEAL M @5ppb; VINSAEL M @ 10 ppb.
- Refer to Loss circulation guidelines / decision tree found in Appendix 1 of this program in the event losses are encountered.
- Severe losses may require pumping MI-SWACO's **Form-A-Squeeze, EZ-Squeeze, or Form-A-Set AK.** Refer to *FAS software* for formulation, mixing and pumping instructions. Mixing in structions can be found in Appendix 7 of this program
- Maintain enough Form-A-Squeeze LCM material on location to build and pump a 200 bbl pill. In the event of loss circulation this pill will be pumped after conventional LCM pills does not heal the formation. Maintain enough EZ-Squeeze material on loaction to build and pump a 200 bbl pill. This will be pumped after a Form-A-Squeeze pill has been pump and does not heal the formation to regain circulation. A technician will have to be flown to rig to mix this pill.
- Maintain enough Form-A-Set AK material on location to build and pump a 200 bbl pill if needed.
- Record rheology at 40 degrees, 100 degrees, and 150 degrees daily and submit on daily mud report in OneTrax.
- At TD pump a 100 bbl viscous sweep and circulate the well bore clean. One circulation is never enough. (See "Procedures – Sweep/Well bore Cleaning") Due to the possibility of large PDC cuttings collecting in the BOP cavities pump another 100 bbls high viscosity sweep at the well head before POOH. The "piston" effect of running the liner through casing may result in mud losses both running the liner and cementing. Ensure that sufficient mud volumes are aboard the rig to run and cement the liner in the event that losses occur. Run "SurgePro" to model running 13⅝" liner.
- Casing will be set in pilot hole so there will not be any 16.5 ppg pad mud spotted on bottom prior to running the 13⅝" liner unless WSL deems it is necessary.

INTERVAL DISCUSSION AND PROCEDURES:

- Continue running PPT daily and report on Mud Report (500 PSI, 90 micron disk, 250°F or BHT if <250).
- Monitor the LCM concentrations with the **Wet Sieve Test**. The fluid specialist on ocation will complete test daily and adjust LCM additions based on the particle size distribution identified based on discussed LCM plan for interval. Testing procedures are included in the program (Appendix 5). Email results to Project Engineer daily.
- The Viscometer Sag Shoe Test (VSST) will be run daily and reported in comments section of Daily Mud Report.
- Should the need arise for additional wellbore cleaning; refer to Appendix 6 of this program.
- Refer to RHELIANT guidelines for chemical additions.
- Track losses in section recap:
  - Bbls lost while P/U and RIH with liner
  - Bbls lost while RIH with liner on landing string
  - Bbls lost while washing the liner to bottom (if required)
  - Bbls lost while circulating after liner landed
  - Bbls lost while pumping and displacing cement.
  - Bbls left behind pipe.

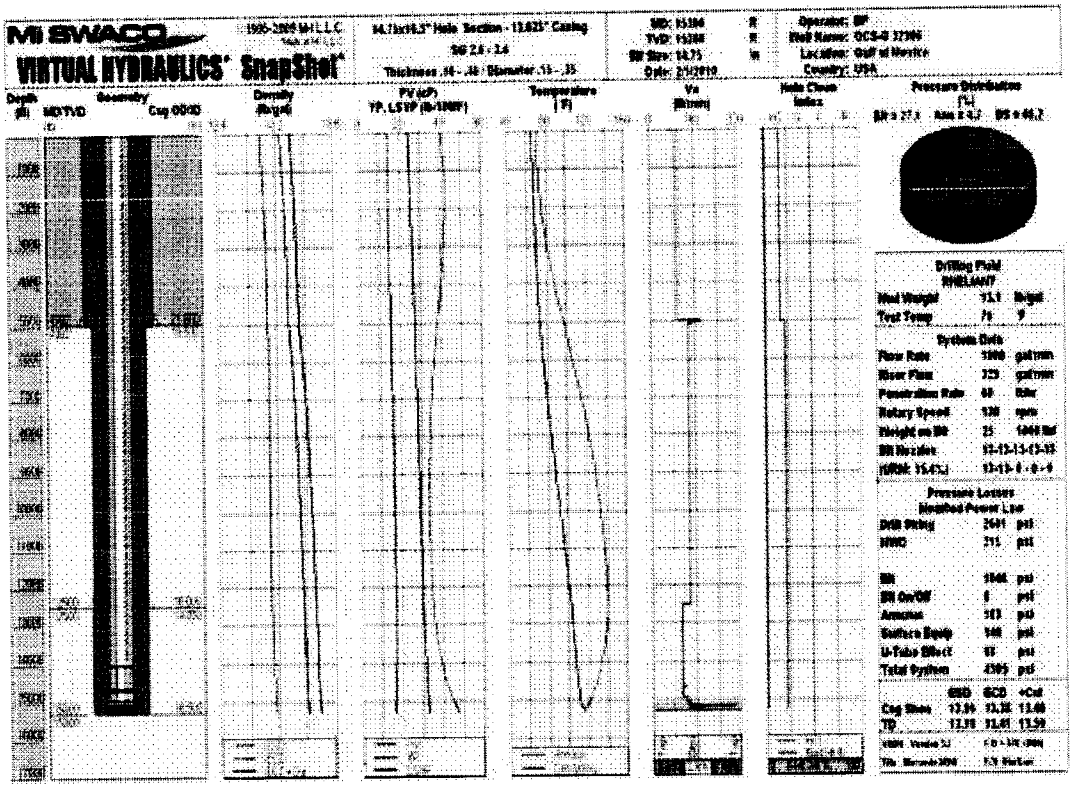
BP HOLE CLEANING MODEL:

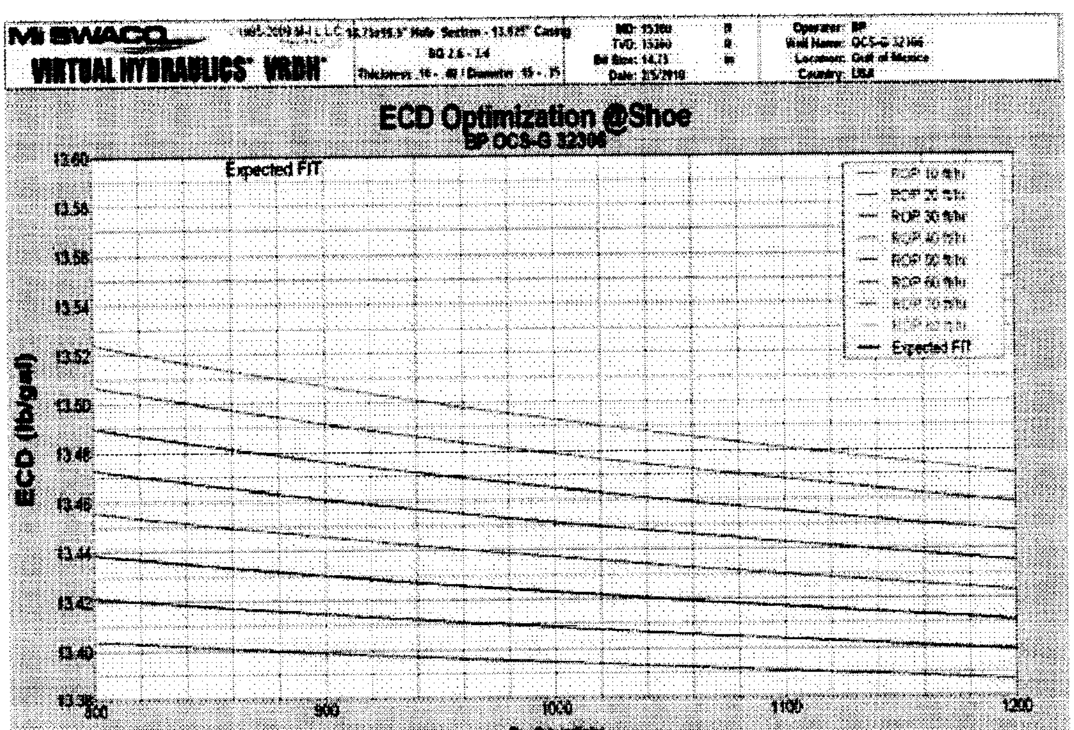


Drilling recommendations for this interval:

- Flow Rate: 800 - 1150 gpm
- Riser Boost: 300 - 350 gpm
- Rotary RPM: 130 rpm; as drilling parameters allow.
- ROP: 20 ft/hr – 100 ft/hr; as well bore conditions dictate

VIRTUAL HYDRAULICS:





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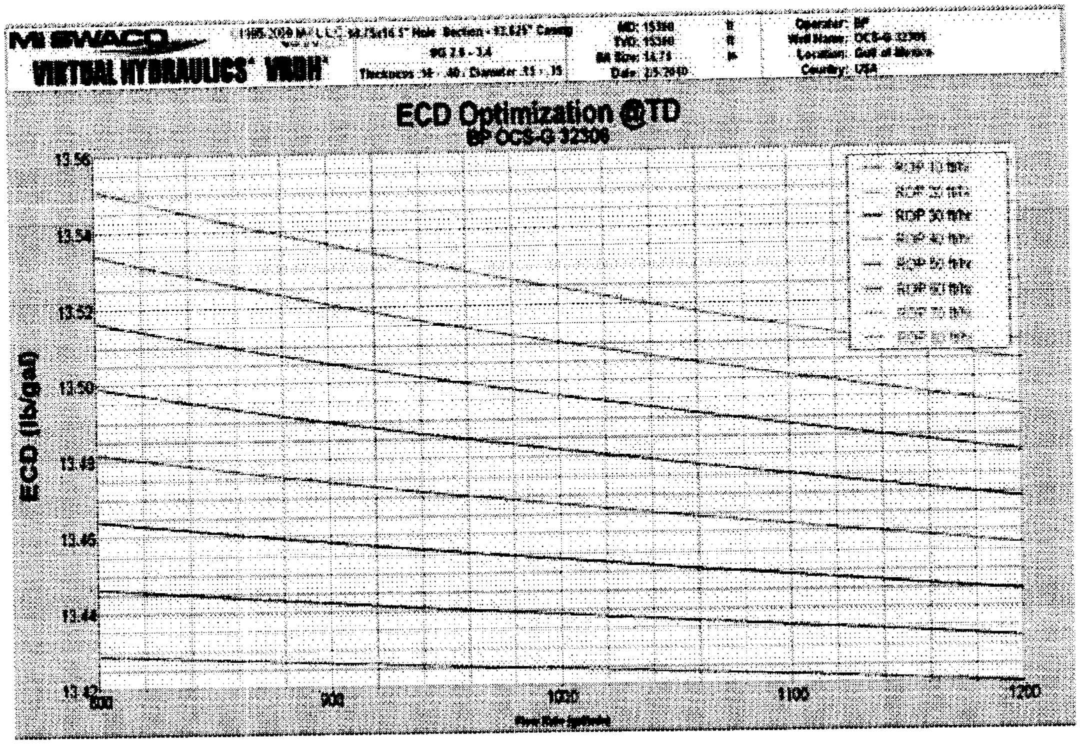

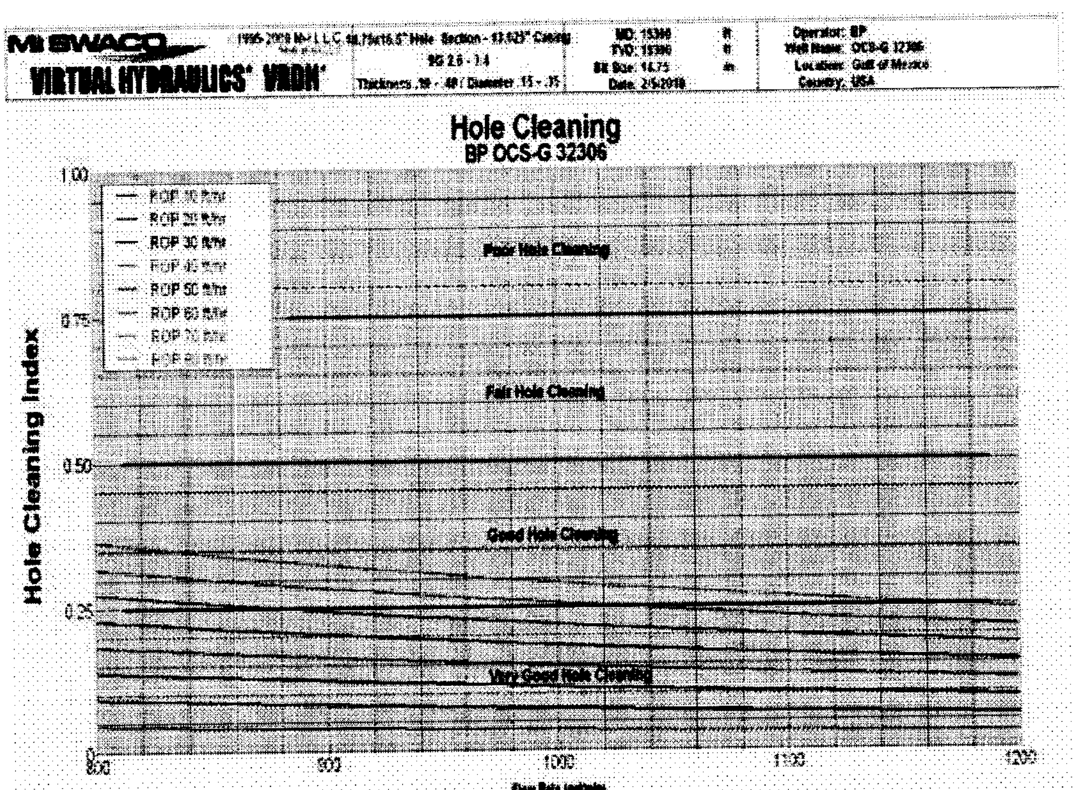

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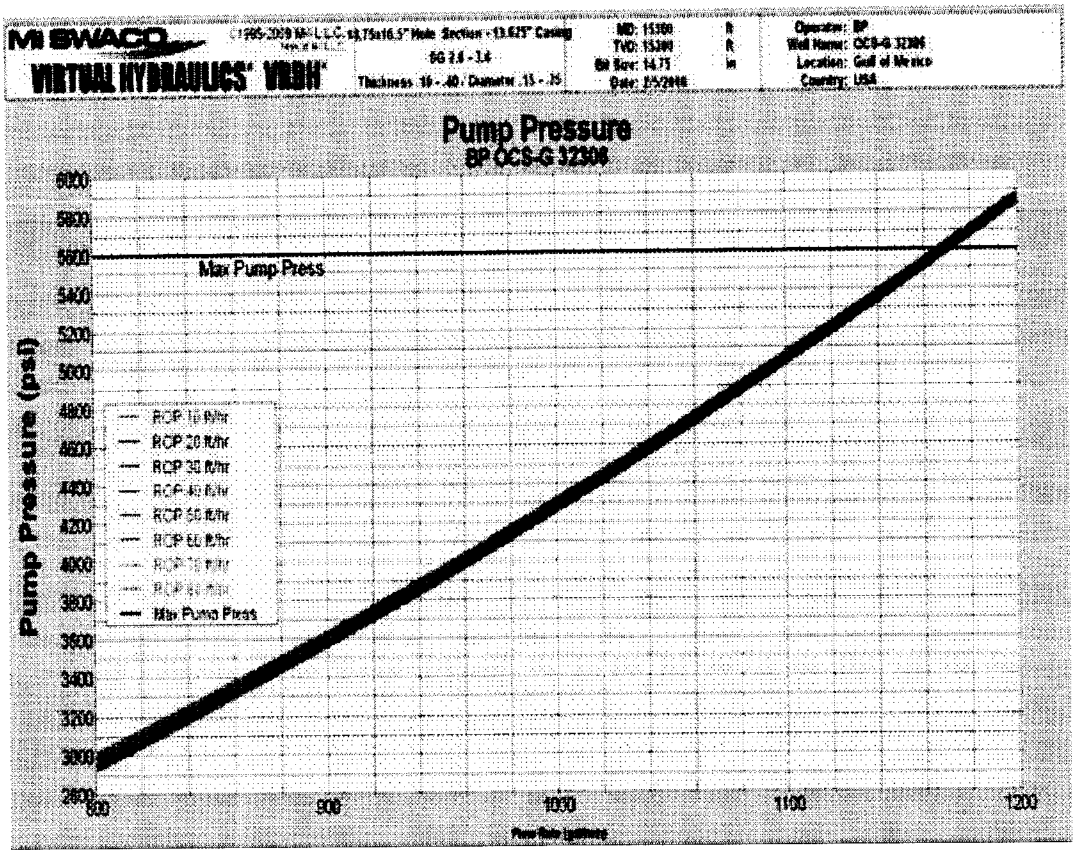


Depth Interval	*15,300' – 19,650' MD/TVD – 12¼"*
Drilling Fluid System	RHELIANT™
Key Products	*M-I BAR, SUREMUL, SUREWET, ECOTROL, RHETHIK, RHEFLAT, RHEDUCE, RHEBUILD,* VG-PLUS / SUPR, $CaCl_2$, Lime, $CaCO_3$ & G-SEAL
Solids Control	**2 x Scalping Shakers, 4 x Linear Motion Shakers (165 mesh screens), 2 Hi G Mud Cleaners, M-I SWACO auger, dryer and centrifuge**
Potential Problems	**Losses to formation.**

INTERVAL DRILLING FLUID PROPERTIES	
Mud Weight (ppg):	**13.1 – 14.2**
Plastic Viscosity (cps):	**25 – 30**
Yield Point (lbs/100ft²):	**12 – 14**
Gels (lbs/100ft²): (10S/10M)	**15 – 25/30 – 35**
3/6 RPM (Fann Units):	**9/8 – 11/10**
HTHP Fluid Loss (ml/30min):	**< 3.0 ml @ 250 degrees**
P_{SM} (ml .02N H_2SO_4):	**1.0 – 2.0**
Chlorides Whole Mud (mg/l):	**35K – 40K**
Salt (% by wt):	**18 – 22%**
Lime (ppb):	**2.0 – 3.0**
Electrical Stability (volts):	**> 400**
Synthetic/Water Ratio:	**75/25 – 77/23**
Maximum LGS Permitted (%)	**< 8.0% due to background LCM**
Check rheology at 150°F/100°F/40°F (API specifications). Run HTHP at 250°F, 500 psi	

INTERVAL OBJECTIVES:

The 12¼" well bore will be drilled to a setting depth (9⅞" casing) of 19,650'. This section will be drilled with **RHELIANT™** SBM. The need for wireline evaluation of this interval will be determined by real time LWD data. There is a contingency to set 11⅞" liner conventional or expandable if the previous casing shoe is bot drilled deep enough. The decision on which will be set will be decided by team while drilling based on actual conditions. This contingency will not be included in this program.

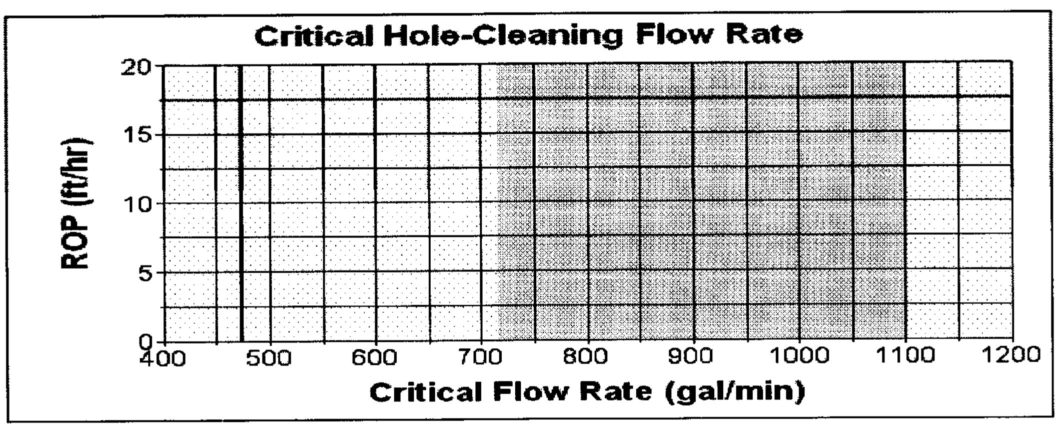
INTERVAL DISCUSSION AND PROCEDURES:

- Rheliant drilling fluids engineering will be substantially the same as in the previous interval.
- Drill shoe track plus 10' of new well bore and obtain an acceptable FIT/LOT (14.7 ppg) to drill ahead to section TD.
- Maintain "flat" characteristic of the system with small additions of "Rheflat" and "Rheduce". Approximately equal 6 & 3, YP across temperature spectrum. Pilot test to confirm appropriate additions and track concentrations in "OneTrax".
- Maintain additions of LCM into system @15 – 17 ppb. Use Standard maintainence mix of Safecarb 250@15ppb, Calcium Carbonate 30/50@15ppb, and G-SEAL PLUS @15ppb totaling 60 ppb in pit. Bleed over into active to maintain 500 lbs/hr in system. We can adjust based on total concentration needed in system. Discontinue use of Safecarb 40 in LCM pit. The system will have enough fines to cover this mocron size.
- Maintain the Emergemy LCM pill (200 bbls @84ppb) and have ready to pump if needed. Build with the following concentrations: G-SEAL PLUS @10ppb; Safecarb 40 @20ppb; Safecarb 250 @20ppb' BLOCK R 750 @14 ppb; KWIKSEAL C @ 5ppb; KWIKSEAL M @5ppb; VINSAEL M @ 10 ppb.
- Refer to Loss circulation guidelines / decision tree found in Appendix 1 of this program in the event losses are encountered.
- Severe losses may require pumping MI-SWACO's **Form-A-Squeeze, EZ-Squeeze, or Form-A-Set AK.** Refer to *FAS software* for formulation, mixing and pumping instructions. Mixing in structions can be found in Appendix 7 of this program
- Maintain enough Form-A-Squeeze LCM material on location to build and pump a 200 bbl pill. In the event of loss circulation this pill will be pumped after conventional LCM pills does not heal the formation. Maintain enough EZ-Squeeze material on loaction to build and pump a 200 bbl pill. This will be pumped after a Form-A-Squeeze pill has been pump and does not heal the formation to regain circulation. A technician will have to be flown to rig to mix this pill.
- Maintain enough Form-A-Set Ak material on location to build and pump a 200 bbl pill if needed.
- Record rheology at 40 degrees, 100 degrees, and 150 degrees daily and submit on daily mud report in OneTrax.
- At TD pump a 100 bbl viscous sweep and circulate bottoms up. One circulation is never enough. By this time, a decision to evaluate well with wireline logs will be made. Monitor bottoms up after circulating the sweep around until well bore is clean to ensure successful wireline logs.
- After logging, a conditioning run to circulate fluid is recommended. Trip back to bottom staging in well bore as deemed necessary by WSL. Logs may take up to a week and fluid has not been circulated during this static time. Once mud is circulated, recommend pumping another 100 bbl viscous sweep and circulate the well bore clean.

INTERVAL DISCUSSION AND PROCEDURES:

- If casing casing is going to be set at td, pump and spot heavey pad mud (16.5 ppg) on bottom prior to tripping out of well bore.
- Continue running PPT daily and report on Mud Report (500 PSI, 90 micron disk, 250°F or BHT if <250).
- Monitor the LCM concentrations with the **Wet Sieve Test**. The fluid specialist on ocation will complete test daily and adjust LCM additions based on the particle size distribution identified based on discussed LCM plan for interval. Testing procedures are included in the program (Appendix 5). Email results to Project Engineer daily.
- The Viscometer Sag Shoe Test (VSST) will be run daily and reported in comments section of Daily Mud Report.
- Should the need arise for additional wellbore cleaning; refer to Appendix 6 of this program.
- Refer to RHELIANT guidelines for chemical additions.
- Track losses in section recap:
  - Bbls lost while P/U and RIH with liner
  - Bbls lost while RIH with liner on landing string
  - Bbls lost while washing the liner to bottom (if required)
  - Bbls lost while circulating after liner landed
  - Bbls lost while pumping and displacing cement.
  - Bbls left behind pipe.

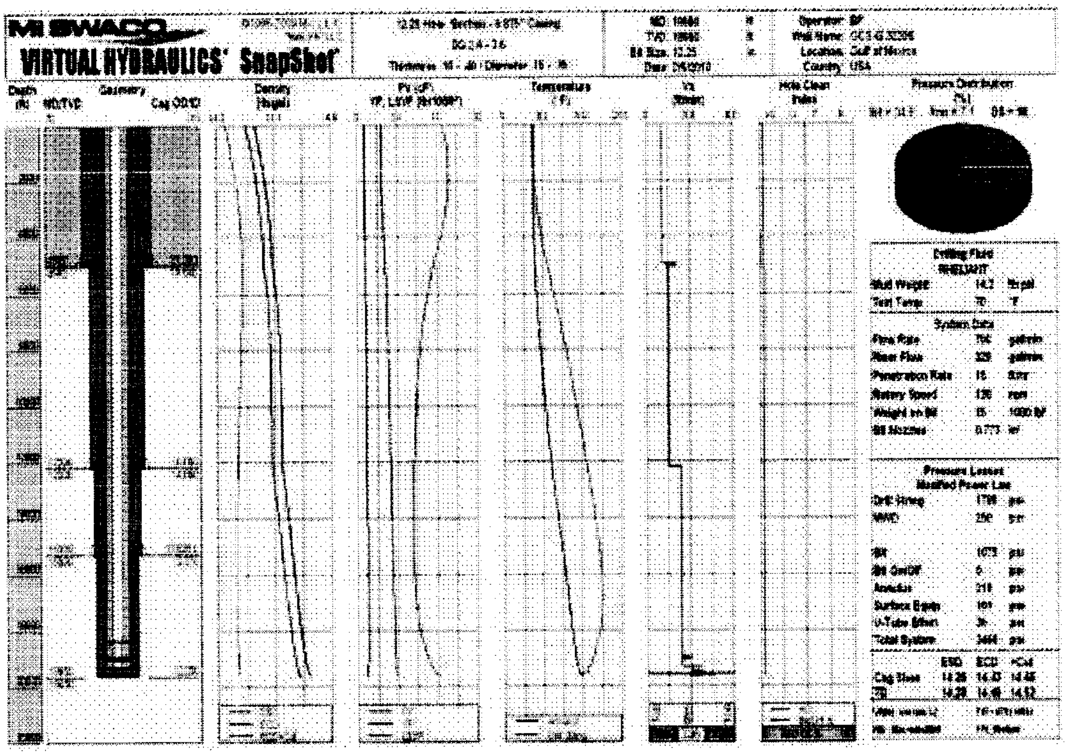
BP HOLE CLEANING MODEL:

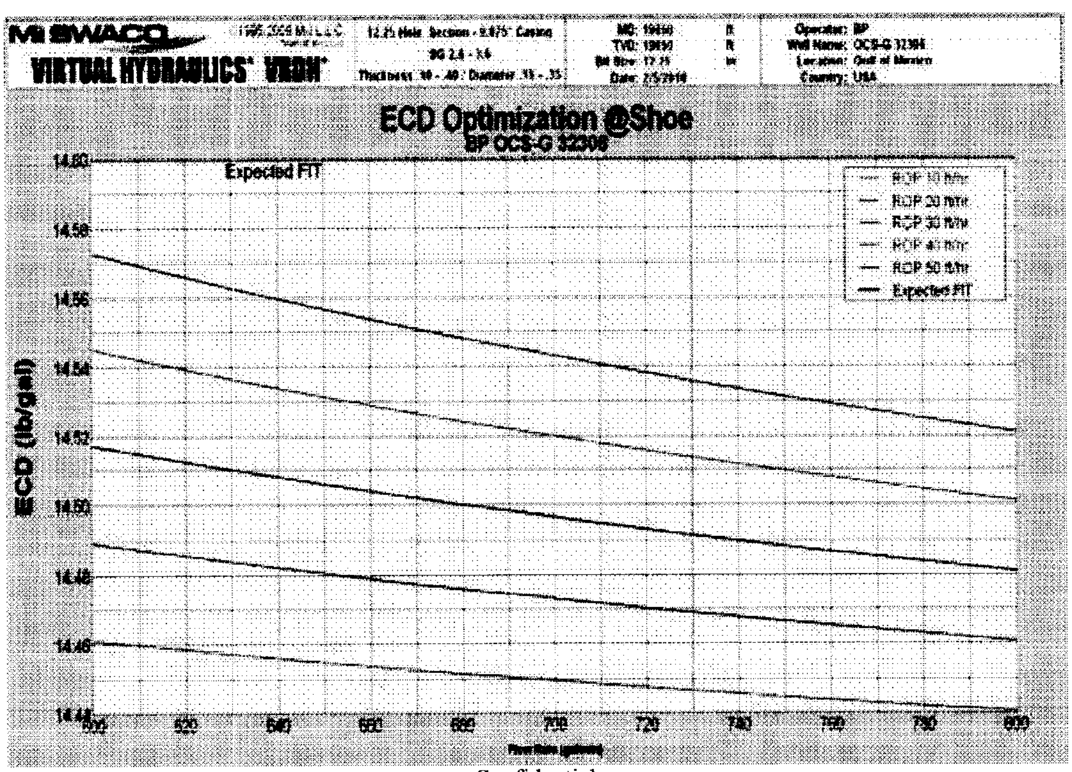


Drilling recommendations for this interval:

- Flow Rate: 700 - 900 gpm
- Riser Boost: 300 - 350 gpm
- Rotary RPM: 110 rpm; as drilling parameters allow.
- ROP: 5 ft/hr – 20 ft/hr; as well bore conditions dictate

VIRTUAL HYDRAULICS:





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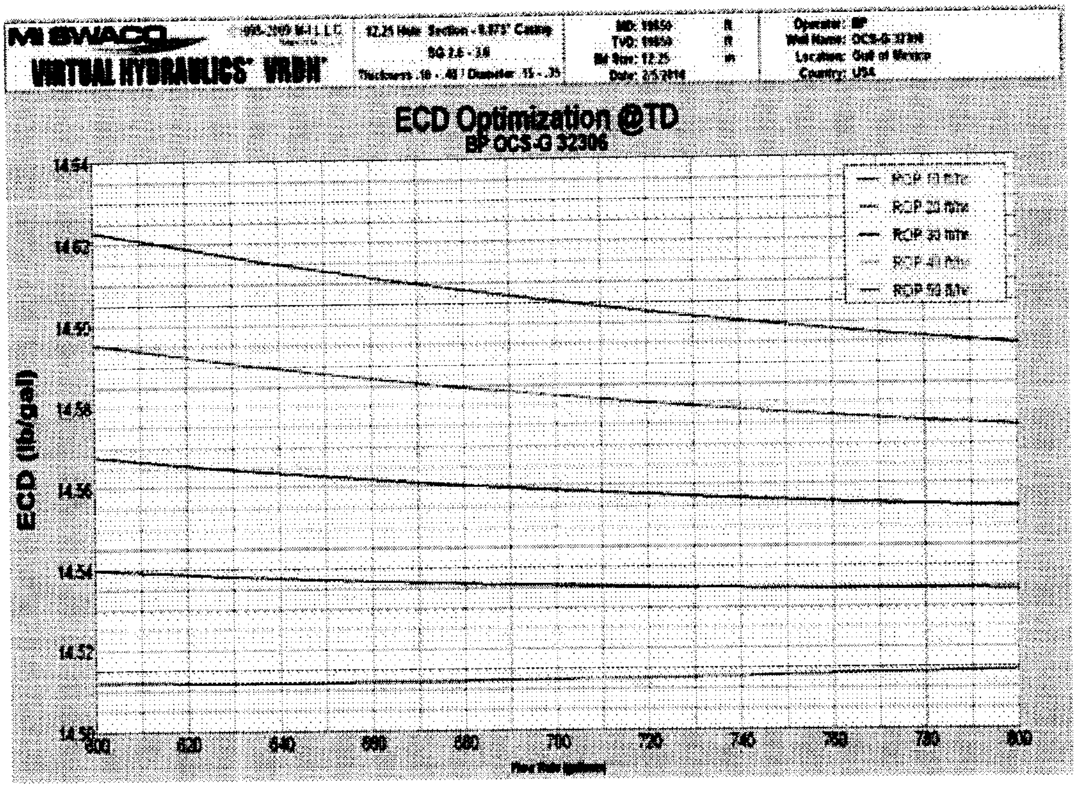

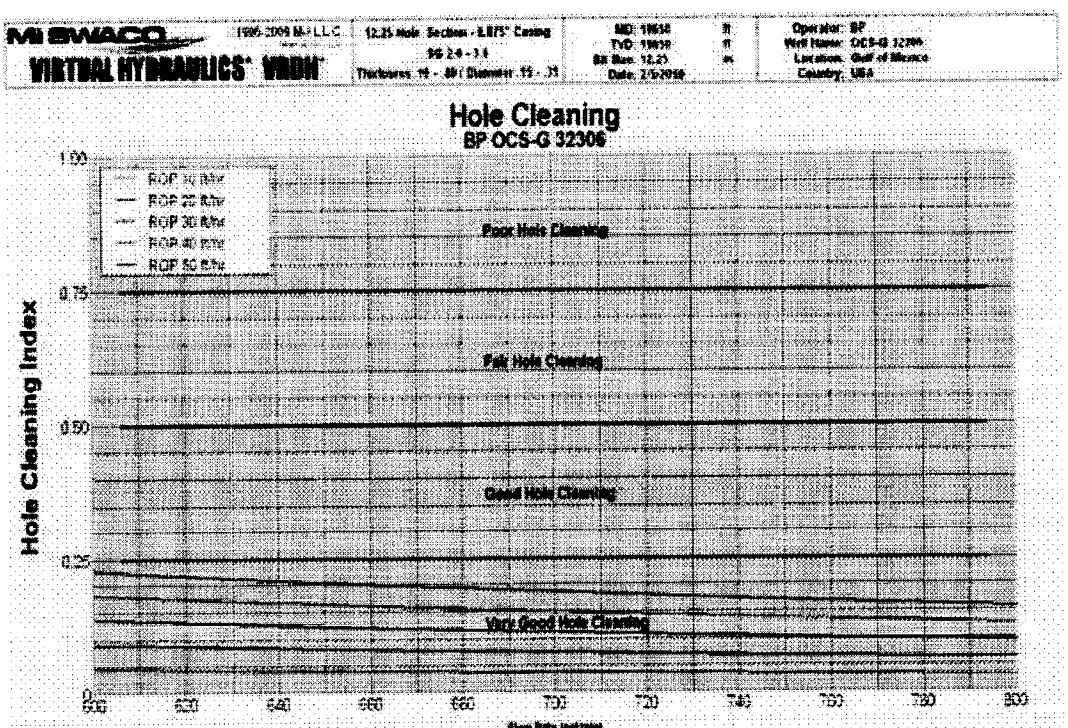

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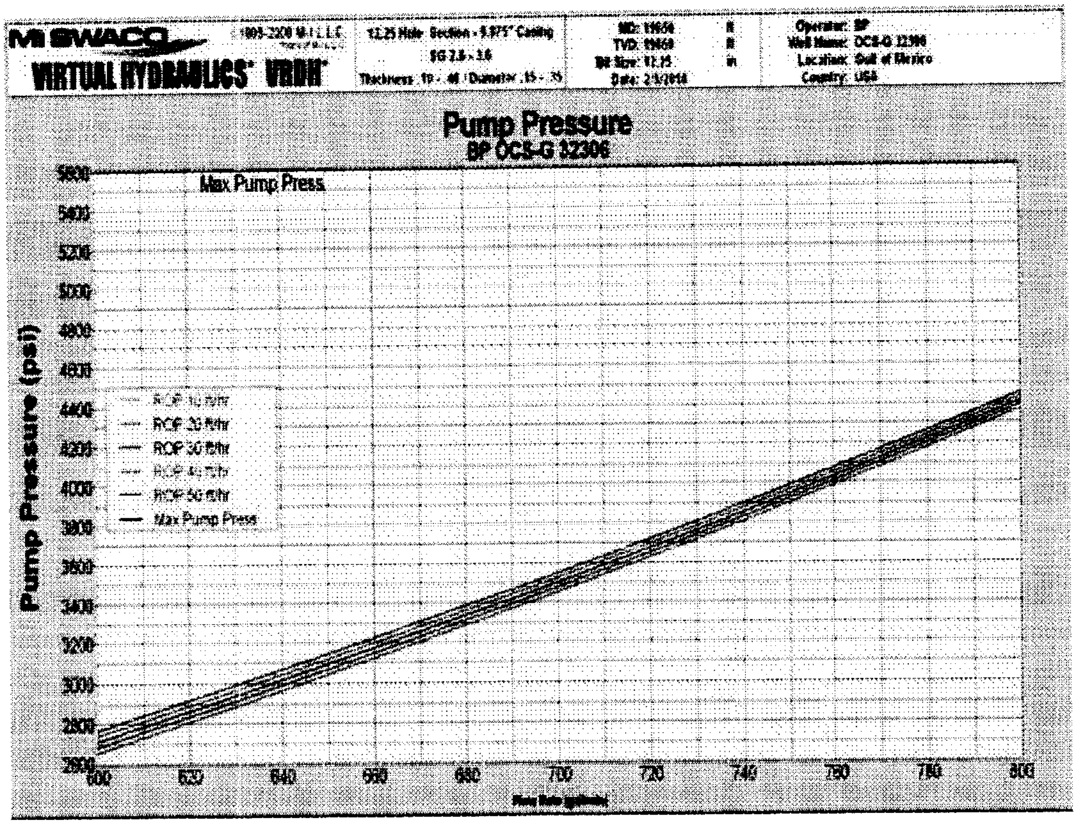


APPENDIX 1 – LOST CIRCULATION RECOMMENDATIONS:

The following proactive lost circulation decision tree can be modified to include any contingencies that BP wants to plan for. The flowchart allows for planning of lost circulation material needs.

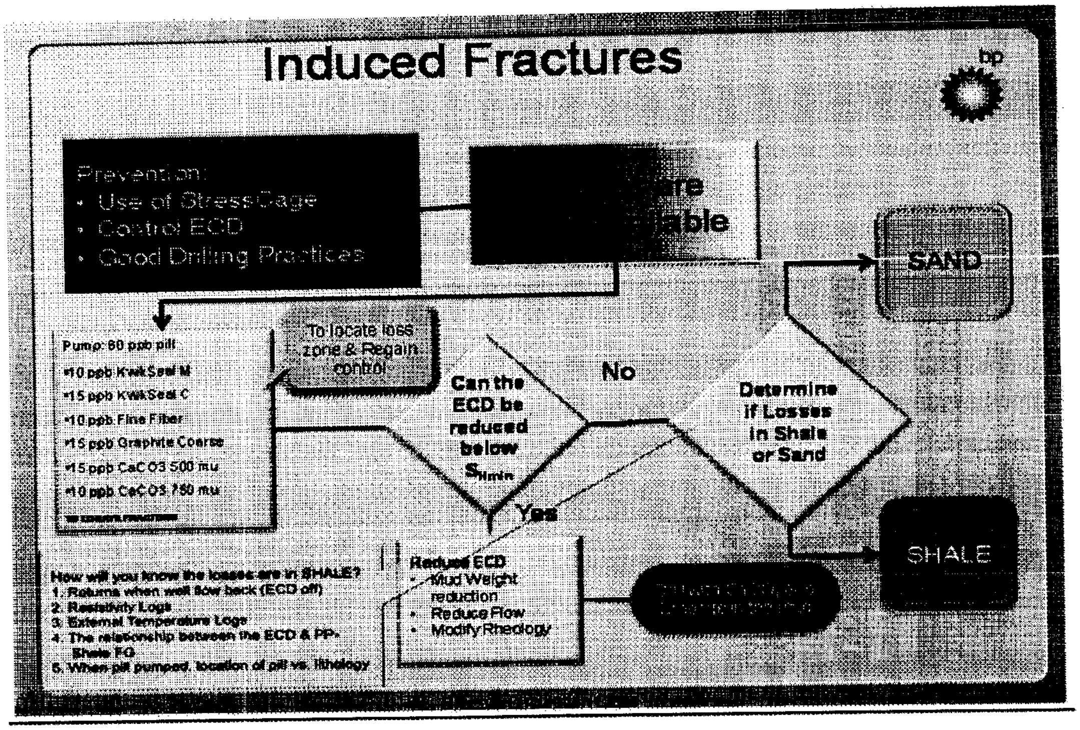
Synthetic mud systems are prone to problems with lost circulation due to their compressibility. In deepwater applications the heavy mud column transfers pressure to the formation. This can be partially overcome with predictive computer software such as VIRTUAL HYDRAULICS and with well bore tools such as PWD.

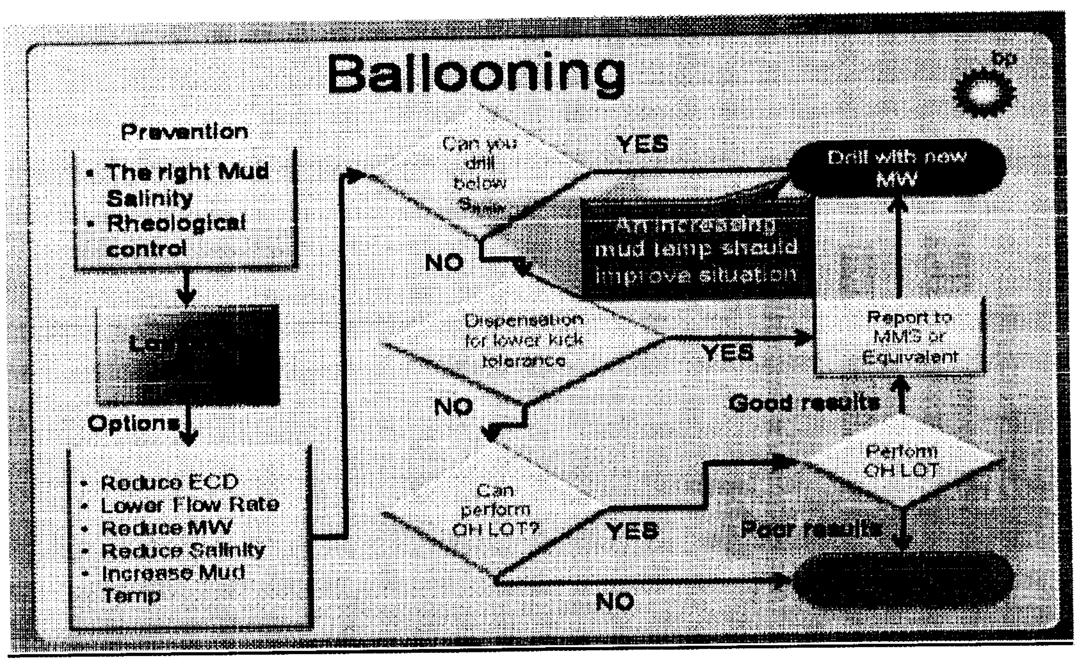
Planning and proper drilling practices are the keys to preventing lost circulation by minimizing excessive pressures on the formation.

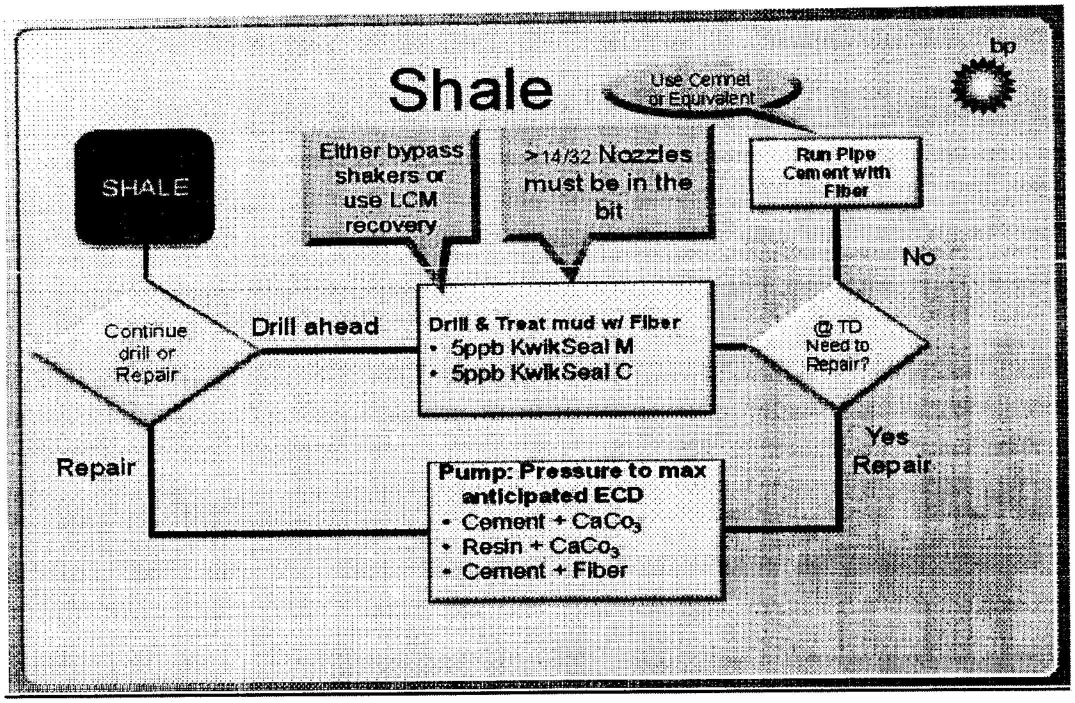
- Minimize well bore pressures – Pipe movement should not exceed critical speeds when tripping. When running in the well bore surge pressure from the piston effect of the bit increases pressures exerted on the bottom of the well bore. The deeper the well, the slower the pipe should be run into the well bore as the depth of the bit increases. The smaller annular clearances also increases surge pressures in much in the same way that annular pressure losses are increased as the annular clearance decreases.
- Avoid Rapid movement of the pipe while circulating. Spudding the pipe or fast reaming while circulating creates large surge pressures.
- High ROP's, loading the annulus with cuttings, increases ECD's and makes for increased surge pressures.
- Rapid starting or stopping of the mud pumps causes pressure surges. The pressure necessary to break the gel structure of the mud causes this surge. Wash and ream cautiously through bridges.
- Avoid kicks. Shut-in pressure at the surface is transmitted through well bore, which could break down the formation at the weakest point.
- Control Mud Properties –
    - Excessive viscosity and gel strengths contribute to surge pressures each time circulation is interrupted and restored. They also increase the ECD while drilling. Optimize values to ensure good well bore cleaning and solids suspension, and minimize ECD and surge and swab pressures.
    - Control low gravity solids at a minimum concentration.
    - Drill with minimum mud density.

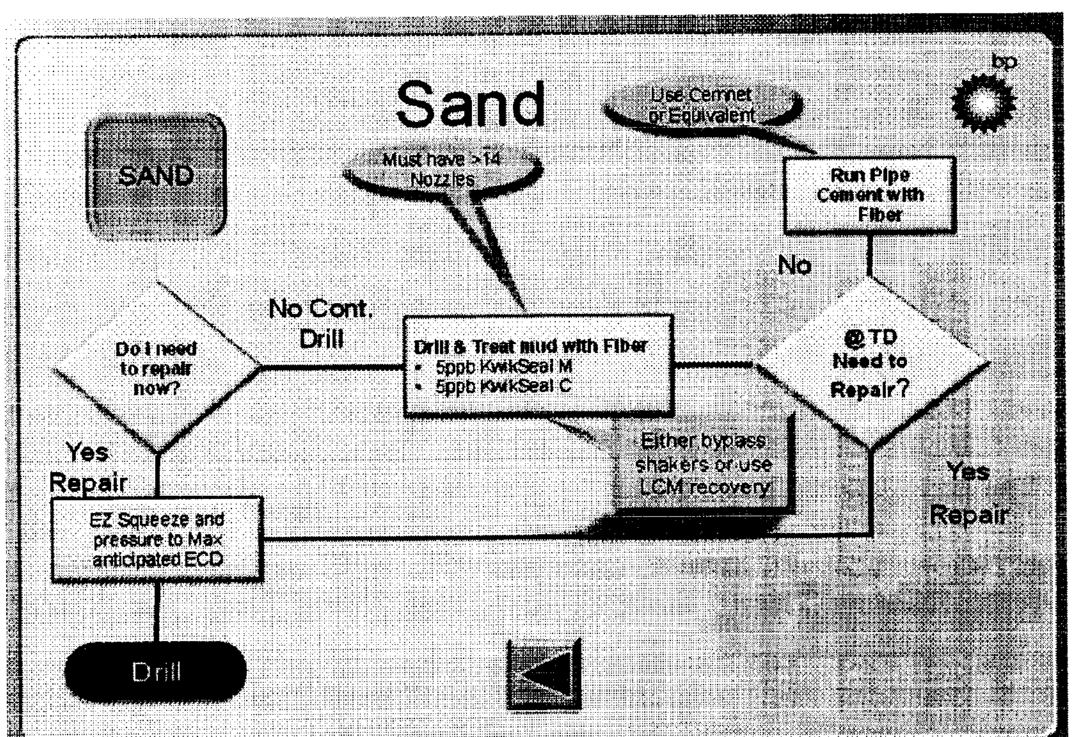
Treatment Scenarios

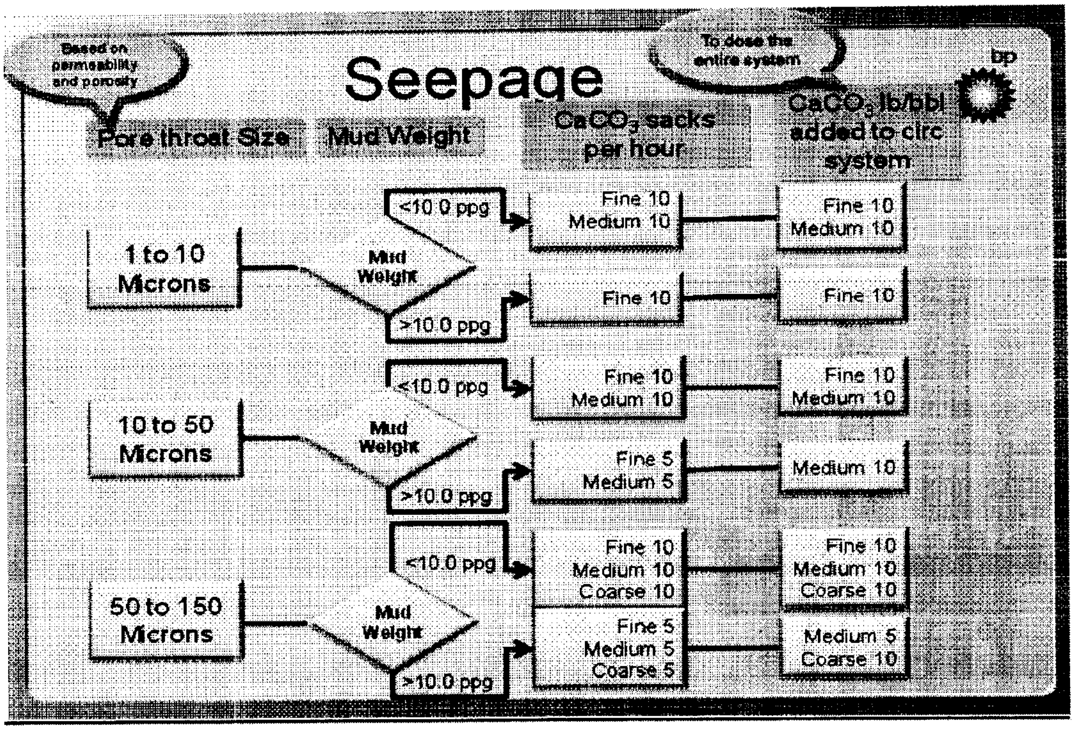
- Seepage
- Natural Fracture
- Induced Fracture
  - Sand
  - Shale
- Ballooning
- Leak at shoe

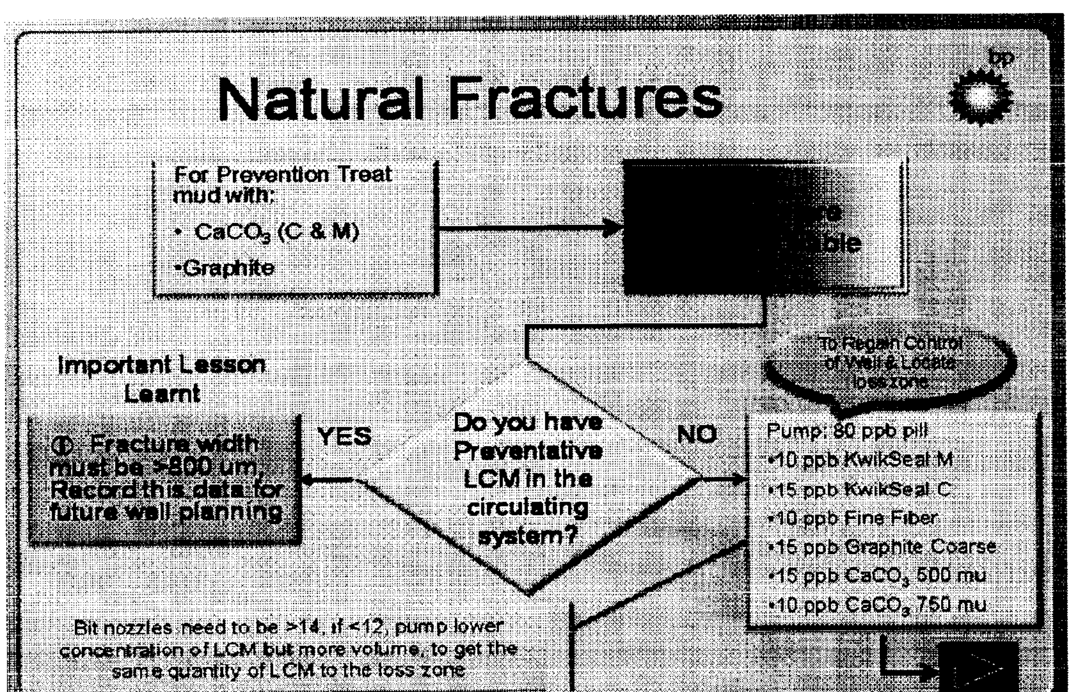

Induced Fractures
bp
Prevention:
• Use of StressCage
• Control ECD
• Good Drilling Practices
SAND
Pump: 80 ppb pill
•10 ppb KwikSeal M
•15 ppb KwikSeal C
•10 ppb Fine Fiber
•15 ppb Graphite Coarse
•15 ppb CaCO3 500 mu
•10 ppb CaCO3 750 mu
To locate loss zone & Regain control
Can the ECD be reduced below Shmin
No
Determine if Losses in Shale or Sand
Yes
SHALE
How will you know the losses are in SHALE?
1. Returns when well flow back (ECD off)
2. Resistivity Logs
3. External Temperature Logs
4. The relationship between the ECD & PP-Shale FG
5. When pill pumped, location of pill vs. lithology
Reduce ECD
• Mud Weight reduction
• Reduce Flow
• Modify Rheology

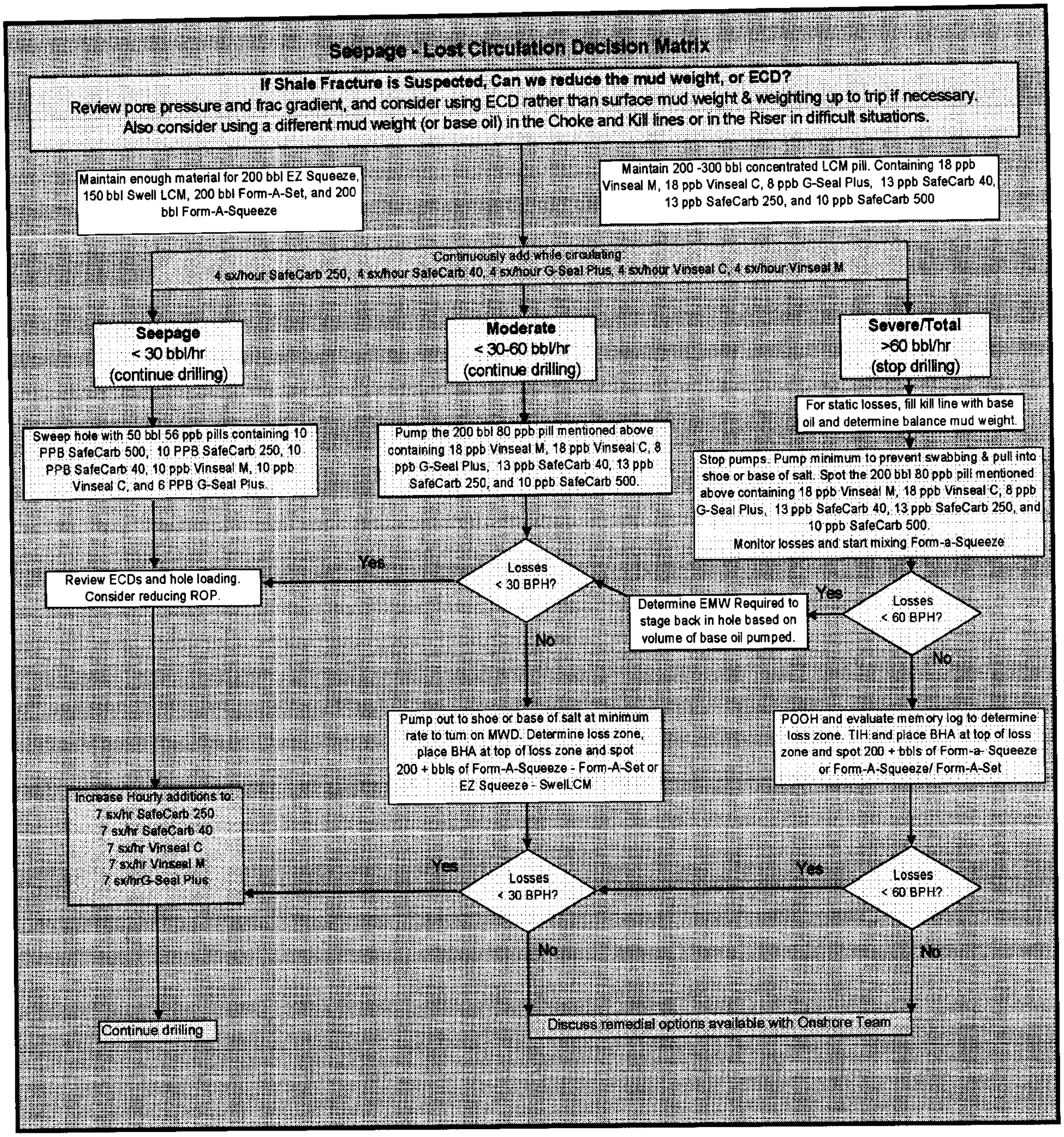

Ballooning
bp
Prevention
• The right Mud Salinity
• Rheological control
Options
• Reduce ECD
• Lower Flow Rate
• Reduce MW
• Reduce Salinity
• Increase Mud Temp
Can you drill below Shmin
YES
Drill with new MW
NO
An increasing mud temp should improve situation
Dispensation for lower kick tolerance
YES
Report to MMS or Equivalent
NO
Good results
Perform OH LOT
Can perform OH LOT?
YES
Poor results
NO


Shale
Use Cemnet or Equivalent
SHALE
Either bypass shakers or use LCM recovery
>14/32 Nozzles must be in the bit
Run Pipe Cement with Fiber
No
Continue drill or Repair
Drill ahead
Drill & Treat mud w/ Fiber
• 5ppb KwikSeal M
• 5ppb KwikSeal C
@ TD Need to Repair?
Repair
Yes Repair
Pump: Pressure to max anticipated ECD
• Cement + CaCo3
• Resin + CaCo3
• Cement + Fiber


Sand
Use Cemnet or Equivalent
SAND
Must have >14 Nozzles
Run Pipe Cement with Fiber
No
No Cont. Drill
Do I need to repair now?
Drill & Treat mud with Fiber
• 5ppb KwikSeal M
• 5ppb KwikSeal C
@ TD Need to Repair?
Either bypass shakers or use LCM recovery
Yes Repair
Yes Repair
EZ Squeeze and pressure to Max anticipated ECD
Drill


Based on permeability and porosity
Seepage
To dose the entire system
bp
Pore throat Size
Mud Weight
$CaCO_3$ sacks per hour
$CaCO_3$ lb/bbl added to circ system
1 to 10 Microns
Mud Weight
<10 0 ppg
>10.0 ppg
Fine 10 Medium 10
Fine 10
Fine 10 Medium 10
Fine 10
10 to 50 Microns
Mud Weight
<10.0 ppg
>10.0 ppg
Fine 10 Medium 10
Fine 5 Medium 5
Fine 10 Medium 10
Medium 10
50 to 150 Microns
Mud Weight
<10.0 ppg
>10.0 ppg
Fine 10 Medium 10 Coarse 10
Fine 5 Medium 5 Coarse 5
Fine 10 Medium 10 Coarse 10
Medium 5 Coarse 10


Natural Fractures
bp
For Prevention Treat mud with:
• $CaCO_3$ (C & M)
•Graphite
Important Lesson Learnt
① Fracture width must be >800 um, Record this data for future well planning
YES
Do you have Preventative LCM in the circulating system?
NO
To Regain Control of Well & Locate loss zone
Pump: 80 ppb pill
•10 ppb KwikSeal M
•15 ppb KwikSeal C
•10 ppb Fine Fiber
•15 ppb Graphite Coarse
•15 ppb $CaCO_3$ 500 mu
•10 ppb $CaCO_3$ 750 mu
Bit nozzles need to be >14, if <12, pump lower concentration of LCM but more volume, to get the same quantity of LCM to the loss zone



Confidential

APPENDIX 2 - MINIMUM TIME TO CIRCULATE PRIOR TO POOH:

The BP model simply predicts the minimum flow rate required for adequate cuttings transport. No predictions are available for the rate at which cuttings are removed. Because the cuttings move more slowly than the circulating mud, it is essential that sufficient bottoms-up are circulated prior to tripping. A SINGLE BOTTOMS-UP IS NEVER ENOUGH!

The minimum on bottom circulation time prior to tripping will be influenced by well bore size, inclination and flow history (i.e. mud properties and flow rate). These factors will affect the height of any residual cuttings beds. Recent work by Exxon has indicated that the volume of cuttings left behind during normal drilling operations can be considerable. They recommend selection of bits/BHAs with large bypass areas to facilitate tripping out of the well bore.

Before tripping, monitor the shakers to ensure the cuttings return rate is reduced to an acceptable background level. The figures in the table below are guidelines based on simple slip velocity considerations and field experience:

WELL INCLINATION RANGE	SECTION LENGTH FACTOR		
	17-1/2 inch WELL BORE	12-1/4 inch WELL BORE	8-1/2 inch WELL BORE
0° - 10°	1.5	1.3	1.3
10° - 30°	1.7	1.4	1.4
30° - 60°	2.5	1.8	1.6
60° +	3.0	2.0	1.7

PROCEDURE

1. Effective length = Section length x section length factor.
2. Circulation time = $\frac{\sum \text{Effective Length}}{\text{Measured depth at Bit}} \times \text{B/U}$
3. Since in practice not all of the section back to surface will be deviated at the same angle, the overall minimum circulation time prior to tripping should be apportioned in direct relation to the relative lengths of section at each angle.

APPENDIX 3 - HSE ISSUES:

SAFETY RECOMMENDATIONS FOR RHELIANT SYSTEM

1. The rig crew should be briefed on the nature of **RHELIANT** and its cost. Safety and care should be used when drilling with **RHELIANT** or any drilling fluid. An M-I Engineer will brief rig crews about **RHELIANT** and basic safety procedures.
2. MINIMIZE contact with the drilling fluid. **RHELIANT** contains Calcium Chloride and Lime and although it's non-toxic, it can irritate skin.
3. Wear personal protective equipment when you must work with the mud. Proper equipment includes: a. Safety glasses or goggles; b. Hard hat; c. Steel toed boots or shoes (recommend rubber for shaker and drill crew); d. Protective clothing (disposable suits or slicker suits); e. Barrier cream; f. Rubber gloves

Note: As always, follow the rig and operators safety rules.

4. If you get mud on your skin, wash it off as soon as possible. Do not allow mud to stay in contact with your skin for longer than 30-40 minutes. Do not wash with rig soap! Use GOJO mechanics degreaser or other similar type product.
5. If clothing becomes saturated with **RHELIANT**, then change your clothes. Do not continue to work in clothes saturated with mud.
6. Designate one rig washing machine for muddy clothes. Do not wash other clothes in this machine.
7. Protective Equipment that has worked well on other jobs: Disposable suites: TYVEK BRAND; Rubber boots: GOODALL BRAND POLY GRIP BOOTS MODEL #A1541; Coverall pants: GOODALL ARMOR LITE OVERALL, MODEL #C2522; Coverall Jacket: GOODALL ARMOR LITE JACKET, MODEL #C2520
8. People tend to become lax in observing the above safety guidelines because **RHELIANT** has no offensive odor and is not unpleasant to work around. **Common sense when working with RHELIANT will prevent any safety problems.** If you get RHELIANT on you, wash it off. If you have to work with or around the mud, wear your protective equipment. Watch your step and clean up any spills.

APPENDIX 4 - RECOMMENDED DRILLING PRACTICES:

GUIDELINES FOR LEAVING RHELIANT IN THE WELL BORE FOR EXTENDED PERIODS

The following suggestions are the result of a survey of Deepwater Operators of the procedures/mud properties they use to minimize losing circulation after being out of the well bore for extended periods such as logging programs:

MUD PROPERTIES:

1. Yield Point – Keep YP >25-35 @ 150° F.
2. Low shear rate viscosities – The 3 & 6 rpm Fann VG meter readings should be 15-20 @ 150° F (MI's R & D group study of barite sag indicates that doing this minimizes sag).
3. Yield Points and low shear rate viscosities can be run lower to maximize the solids removal efficiency of mud cleaners while drilling. Raise rheology prior to leaving mud in the well bore for long periods of time.
4. Recommend lowering rheology prior to running casing with the use of ***IO 16/18*** base fluid and ***RHEDUCE*** product. Use Virtual Hydraulics program model to determine rheology levels needed to run the casing.

OPERATIONAL PROCEDURES:

1. Stage into open well bore several increments breaking circulation each time and circulating for a period of time to get the fluid moving. The bottom of the riser section should be the first to be circulated due to the high gel strengths generated by the cold water outside the riser.
2. Idle pumps when beginning circulation to minimize surge pressures
3. Work pipe and rotate while circulating to help break up gel strengths
4. Look for signs of barite sag when staging in the well bore. Light mud near the riser section could be indicative of a sag problem. If sag is a problem, the depth increment for staging might have to be shortened to prevent lost circulation plems.

Deviated well bores will have a tendency to aggravate barite sag problems. These type sections may require higher yield points or low shear rate viscosities than the above recommended ranges to compensate for this tendency.

APPENDIX 5 - WET STACKED SIEVE - PROCEDURE / REPORTING:

Objective

Our objective is to measure the particle size distribution and the lb/bbl concentration of LPM-sized materials in drilling fluid samples taken from the suction pit (this represents what is being sent down well bore) using a stacked-wet-sieve onsite method, and to validate this method by further analysis (dried weight, XRD and Coulter PSD) of split samples sent to our Houston lab.

Sampling Plan

A drilling fluid sample will be taken once per tour and will be analyzed using the stacked-wet-sieve method described herein. A one-quart split Drilling Fluid sample will be collected on the first test and every seventh day's test thereafter, and sent to Houston for analysis. Drilling Fluid samples will be identified with *Source/Date/Time.* Split sample containers will be similarly labeled.

During the stacked-wet-sieve test, solid material is collected on the sieves and each sieve is flushed to a separate 100 ml glass receiver for analysis. On the first test, and every seventh day's test thereafter, sieved material samples will be collected and sent to Houston for analysis. This material will be identified with *Sieve Size / Source/Date/Time.* Sieved material sample containers will be similarly labeled.

Test Procedure

Collect and properly label an 8 oz Drilling Fluid sample and an 8 oz split sample once per tour while drilling. Take this sample at the same time and location as the "suction pit mud check sample". Label samples with Name/Location/Date/time (e.g. MC-776 #5/Suction/102407/1500).

Load the Portable Wet-Sieving device with the following clean sieves (in order of top to bottom): 710, 500, 250,106, and 75 micron sieves. Tighten and secure sieves to prevent fluid bypass. Label each 100 ml container to correspond with the sieve size.

Pour 100 ml of this sample into a container and dilute with base oil until it can slowly be poured through the stacked sieves. Make sure that all particles are washed from the container. Flush the particles using a squirt bottle filled with base oil from each sieve into the corresponding 100 ml container.

Fill the container to the 100 ml mark with base oil. Pore the entire contents of this glass tube into the Wet-Sieving device, flushing the glass tube with base oil as required to ensure its entire contents is transferred to the Portable Wet-Sieving device.

Carefully extract the stacked sieves from the Portable Wet-Sieving device without spilling any of solid material collected on each of the sieves. Place each sieve in a clearly labeled location to indicate its sieve size. Assign and label a clean 100 ml glass tube to each of these sieves, and place in a rack designed to hold them.

Carefully wash the material collected on each sieve into the designated 100 ml glass tube, using a squirt bottle of base oil to flush the screen, and a funnel to collect the entire material into the glass tube. Fill all tubes to the same height. *We recommend you load all properly labeled 100 ml glass tubes before proceeding to the centrifuging step in order to optimize process time.*

Load the hand-crank centrifuge with any two of these tubes and centrifuge for one minute. *We recommend taking 5 seconds to come up to a speed of one rotation per second, then holding that speed for the next 60 seconds.*

Remove the tubes from the apparatus and <u>record the apparent volume</u> of solid material in mls for each tube.

Replace either tube in the apparatus with the next, un-centrifuged tube, and repeat the spinning process.

<u>Remove the most recently added tube</u> from the apparatus and <u>record the apparent volume</u> of solid material in mls.

On the first test, and each fourth day's test thereafter, flush the entire contents of each glass tube to a separate sample container, properly labeled, and send to Houston for further analysis. Do not intermix or commingle the contents of the different glass tubes.

<u>Reporting</u>
Maintain spreadsheet created for this project. (See addendum)

<u>Lab Analysis</u>
Data will be generated that may influence factors used on your reporting spreadsheet, especially the Bulk Density Factor, and possibly the Particle Size Distribution curve. Specific guidance will be provided should any adjustments to your sampling plan or reporting worksheet be required.

Attachments:

Addendum: Wet Sieve Reporting Worksheet

You may hide any sample column(s) to simplify printing and charting EXCEPT for the three columns on which this message is written

Use this bulk density figure: 1.1

MI SWACO

Sieve	Opening	Opening	Total ppb LCM in Mud from Active Pit (APl012208 /1300/COB) 100.0 ml	LBS/BBL	THE FOUR DIFFERENT MICRON SIEVE SIZES USED IN TESTING (APl012208 /1200/COB) 100.0 ml	LBS/BBL	Total ppb LCM in Mud from Active Pit (APl012208 /2130/COB) 100.0 ml	LBS/BBL	THE FOUR DIFFERENT MICRON SIEVE SIZES USED IN TESTING (APl012208 /2130/COB) 100.0 ml	LBS/BBL	Total ppb LCM in Mud from Active Pit (APl012308 /0236/COB) 100.0 ml	LBS/BBL	THE FOUR DIFFERENT MICRON SIEVE SIZES USED IN TESTING (APl012308 /0236/COB) 100.0 ml	LBS/BBL	Total ppb LCM in Mud from Active Pit (APl012308 /2045/COB) 100.0 ml	LBS/BBL	THE FOUR DIFFERENT MICRON SIEVE SIZES USED IN TESTING (APl012308 /2046/COB) 100.0 ml	LBS/BBL	Total ppb LCM in Mud from Active Pit (APl012608 /0416/COB) 100.0 ml	LBS/BBL	THE FOUR DIFFERENT MICRON SIEVE SIZES USED IN TESTING (APl012608 /0415/COB) 100.0 ml	LBS/BBL
18	1000	1000																				
20	841	850																				
25	707	710			0.2	0.8			0.2	0.8			0.2	0.8			0.3	1.2			0.3	1.2
30	595	600																				
35	500	500			1	3.9			1.2	4.6			1.3	5.0			1.8	6.9			1.3	5.0
40	420	425																				
45	354	355																				
50	297	300																				
60	250	250			1.9	7.3			2.2	8.5			1.9	7.3			1.8	6.9			2.4	9.2
70	210	212																				
80	177	180																				
100	149	150			1.8	6.9			2.1	8.1			2.2	8.5			1.4	5.4			1.7	6.5
120	125	125																				
140	105	106																				
170	88	90																				
200	74	75	6	23.1			5.5	21.2			7.5	28.9			6.5	25.0			7	27.0		
This field contains LPM (lbm/bbl) Larger than (microns)			23 ppb 75		19 ppb 160		21 ppb 75		22 ppb 150		29 ppb 75		22 ppb 150		25 ppb 75		20 ppb 160		27 ppb 75		22 ppb 150	

	Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size		Conc > micron size	
	micron	ppb	micron	ppb	micron	ppb	micron	ppb	micron	ppb	micron	ppb	micron	ppb	micron	ppb	micron	ppb	micron	ppb
Operator: BP	75	23.1	710	0.8	75	21.2	710	0.8	75	28.9	710	0.8	75	25.0	710	1.2				
Well Designation: 1663642			500	4.6			500	5.4			500	5.8			500	8.1				
			250	11.9			250	13.9			250	13.1			250	15.0				
			150	18.9			150	21.9			150	21.6			150	20.4				
Drilling Unit: Ocean Confidence																				
Personnel Onboard																				
Other																				

1000	0.0	0
850	0.0	19.25
710	0.0	0
600	0.0	0
500	0.0	0
425	0.0	23.1
355	0.0	0
300	0.0	0
250	0.0	3.85
212	0.0	0
180	0.0	0
150	0.0	11.55
125	0.0	0
106	0.0	0
90	0.0	15.4
75	0.0	0

APPENDIX 6 - SWEEP/WELL BORE CLEANING:

Particle Transport in Drilling Environments

A significant factor affecting particle transport is well bore angle. Three basic environments exist in the wellbore in which particle behavior varies. These environments can be further differentiated according to particle settling characteristics:

Type	*Behavior*
Vertical, or near vertical – < 20 degrees of well bore angle	Particles settle within the fluid, settling rates are generally low.
Deviated – between 20 and 70 degrees of well bore angle	Particles settle out of the fluid, contact the well bore wall and rapidly slide downwards. (Boycott Settling)
Horizontal –	Particles settle out of the fluid but do not move after this.

The behavior of accumulated cuttings under static conditions in these regions, vertical, deviated, and horizontal, needs to be appreciated, reviewed, and appropriate well bore cleaning strategies considered. For the purpose of this discussion vertical and deviated well bores will be discussed.

Vertical and Near Vertical Intervals

In near vertical well bores the cuttings particles generally remain in suspension the entire time that they are in the wellbore. When the pumps are on and the drill string is rotating the particles may be assumed to be distributed uniformly throughout the fluid, though variations in cuttings concentration with measured depth may occur with varying rates of penetration. In addition, cuttings may accumulate at higher concentrations in regions where the well bore diameter is enlarged and the annular velocity subsequently decreases such as in a washout or in the riser.

Most well bore cleaning problems in vertical wells occur due to excessive ROP overloading the annulus. Overloading the annulus with cuttings can lead to a number of problems. In deepwater environments where the fracture gradients are typically low, a high ROP and a high concentration of cuttings can result in an ECD greater than the fracture gradient leading to formation breakdown and loss of fluid. A second problem that is associated with high ROP is cuttings settling out around the BHA during connections. If the concentration of cuttings is high, the settled cuttings can lead to a pack off around the BHA during connections and subsequent breakdown of formation when drilling resumes. This problem can often be avoided by circulating for a brief period before the connection to get the cuttings to move up the well bore allowing an opportunity for the cuttings to clear the BHA.

When drilling with an invert such as RHELIANT the cuttings shape is finger like in appearance, that is, a high length to diameter ratio. If the bit has aggressive cutters, a high concentration of large cuttings is generated, often resulting in a cuttings build up that can be difficult to manage. A solution to this problem may involve the selection of cutters that are less aggressive and subsequently produce smaller cuttings. Employing this strategy does not necessarily compromise drilling efficiency or ROP but may, in fact, improve the efficiency. The smaller cuttings are easier to transport and improve the rate of cuttings removal from the well.

For vertical wells, high viscosity sweeps are recommended for improving cuttings removal. The high viscosity sweep improves the lifting capacity of the fluid and improves cuttings removal from the annulus. PWD data should be monitored to ensure that the sweep does not generate excessive ECD's. If the ECD does become excessive with the sweep, pump rate should be reduced until the sweep is out of the well bore.

Deviated Intervals

Some of the most troublesome well bore cleaning problems are experienced in deviated wellbores. Particles can typically remain suspended in high angle wells provided the drill pipe rotation is sufficiently high to agitate the cuttings and the annular flow rate is sufficient to provide lift. Problems can rapidly develop under static conditions or if the flow rate and pipe rotation are not adequate, allowing cuttings to accumulate in beds.

The process known as Boycott settling occurs under static or low flow conditions where particles rapidly settle out of suspension in deviated wells, accumulate to a critical mass and avalanche back down the annulus. The avalanching phenomenon can be problematic when making connections. The static flow, settled bed of particles and axial drill string movement create ideal conditions for bed slumping or avalanching.

Back reaming out of the well bore should be avoided unless absolutely necessary so that pack-offs associated with Boycott settling are not induced. Back reaming out of the well leads to a build up of cuttings in the build section of the well. When this build up of cuttings reaches a critical mass, avalanching can occur. The preferred practice is to circulate on bottom with drill string rotation until the well is clean. This eliminates the static period when breaking down the drill string and does not provide an opportunity for Boycott settling. Back reaming should only be applied if a tight spot is encountered that cannot be eliminated after a period of rotating and circulating.

If well bore cleaning is insufficient with high viscosity sweeps for whatever reason, weighted **sweeps** become the pill of choice for improving well bore cleaning performance. The weighted sweep is able to better penetrate regions of the annulus below the drill string that may not have the necessary flow to move cuttings that have entered this region. This problem originates from an eccentric drill pipe. In deviated wellbores the drill pipe is not centrally located. Typically, the drill pipe will be positioned in the lower portion of the well bore. This will result in a skewed distribution of the flow in the annulus, with more fluid flowing over the top of the drill pipe and little fluid flowing underneath. Drill pipe rotation can help to minimize the eccentricity of the pipe, as well as providing a mechanism to direct flow through the lower portion of the wellbore.

The recommended increase in mud density for weighted sweeps is 2 to 4 ppg over the current mud weight. Care should be exercised when formulating weighted sweeps to ensure the additional barite is oil wet if using a RHELIANT system. It is most important to ensure only one weighted sweep is in the wellbore at any one time. This is recommended to ensure the ECD does not exceed the fracture gradient (due to the hydrostatic pressure associated with the sweep and the potential for the sweep to pick-up an excessive amount of cuttings).

Weighted sweeps can also be applied safely in deepwater. A 14 ppg sweep applied in a 10 mud system typically has a small effect on hydrostatic pressure. For an 8,000 ft TVD well with a 10 ppg fluid system, the hydrostatic pressure is approximately 4,160 psi. Including a 250 ft sweep of 14 ppg increases the hydrostatic to 4,212 psi, equivalent to 10.125 ppg. Given typical pressure surges associated with drilling operations, this increase in pressure should be tolerable. One aspect that must be considered, and monitored using real time APWD data, is the impact the cuttings carried by the sweep will have on the ECD. Field data suggests that the additional increase in ECD due solely to the cuttings is in the range of 0.1 to 0.2 ppg, assuming good well bore cleaning practices have been applied. If a sweep is applied after determining well bore cleaning has been poor, higher increases in ECD may be seen until the excessive cuttings are removed from the well. If the sweep picks up too much cuttings the ECD could become excessive. Under these circumstances, flow rate can be reduced to ease the load on the wellbore.

LCM in Sweeps

Lost Circulation Material (LCM) can also be used as a tool to improve cuttings removal from the well. If discrete particles are causing problems, fibrous material such as M-I-X-II can be included in sweeps, weighted and high viscosity, to assist in lifting particles out of the well. When silt beds develop, usually a mixture of barite and fine shale, NUTPLUG is able to erode the silt bed whereas the fibrous network of M-I-X II provides greater lifting force to individual particles. The recommended concentration of either M-I-X II or NUTPLUG is 10 to 15 lbs/bbl.

Low Viscosity Sweeps

Low viscosity sweeps are not recommended. The concept of low viscosity sweeps is associated with lower viscosity fluid inducing turbulent flow across a cuttings bed. This supposedly agitates the cuttings and aids removal. In reality, inducing turbulence with synthetic based mud in a deviated well bore is quite difficult if not impossible.

Sweep Formulation

	Vertical	*Deviated*	*Horizontal*	*Riser*
Angle	< 20 degrees	20 to 70 degrees	> 70 degrees	Vertical
Sweep	High Viscosity	Weighted	Weighted	High Viscosity
Properties	1.5 – 2 X Yield Point	MW + 2 to 4 ppg	MW + 2 to 4 ppg	1.5 – 2 X Yield Point
Volume[1]	200 – 300 ft	200 – 300 ft	200 – 300 ft	80 – 100 bbls
LCM[2]	M-I-X II (C)	M-I-X II (C)	M-I-X II (C)	SUPERSWEEP[4]
LCM[3]	NUTPLUG (C)	NUTPLUG (C)	NUTPLUG (C)	NUTPLUG (C)

1. Volume is open well bore volume, i.e. 200 to 300 ft of open well bore.
2. LCM is to provide discrete particles, which increases lifting capacity.
3. LCM for silt bed provides abrasive action, which increases lifting capacity.

MI SWACO Virtual Hydraulics Well bore Cleaning Model

The well bore cleaning model in VH is fuzzy-logic-based in order to incorporate field/lab data and observations that have not been or cannot easily be modeled analytically. The objective of the model is to determine an index (0-1) that is a relative measure of well bore cleaning difficulty. The results are presented as "very good", "good", "fair", or "poor" (corresponding to index values of 0.0-0.25, 0.25-0.5, 0.5-0.75, and 0.75-1.0, respectively). This unique approach has helped convey well bore cleaning performance to field personnel. The fuzzy-logic model also allows us to look at complex interactions of various factors, such as rotation, eccentricity and LSYP of fluid that are difficult to model analytically.

The basis for determining the well bore cleaning index (HCI) can be easily understood looking at the various well bore inclinations. In a primarily vertical section, there is no cuttings bed, and well bore cleaning is controlled primarily by the amount of cuttings in the flow stream. In those sections, VH uses a classification system typically used in our industry, which says that 0% cuttings (ROP=0) is good, and 5% cuttings is bad. hence a HCI of 0 indicates no cuttings, while an index of 1 indicates 5% (or higher) cuttings concentration in the flow stream.

The other extreme is a near-horizontal section - in such a section, you can have a cuttings bed, but that does not move or slide. In such cases, VH looks at an equilibrium cuttings bed height, and compares that with the amount of flow area available for the cuttings to flow over the BHA if it is reciprocated. For example, if tripping in, the cuttings can pile ahead of the bit - if there is enough flow area for the cuttings to flow back and over the BHA and not pack off, then that is good well bore cleaning. The cutting concentration in the flow stream has an opposite effect here - lot of cuttings in flow stream indicates no cuttings bed, hence that will improve HCI. The overall HCI is then a combination of the available flow area and the concentration in the flow stream.

The last section is the intermediate build sections - in these, VH looks at the tendency of the beds to form and slide down the wellbore, and determines HCI based on those tendencies.

APPENDIX 7 - FORM-A-SQUEEZE:

Form-A-Squeeze is quick and easy lost circulation product that can be used to address severe lost circulation problems while drilling. The high fluid / high solids slurry is a cost effective solution to lost circulation in all types of fractures, vugular formation, matrix and underground blowout events. The slurry is mixed and spotted across the suspected loss circulation zone. After placing the slurry in and/or across a loss zone, the liquid phase is squeezed from the slurry, rapidly forming a solid plug in the loss zone. This process can cure losses instantly, without the need for time and/or temperature like the **Form-A-Set AK** pill.

System Highlights:

- Single sack system – No additional products required for suspension or activation.
- Extremely easy to mix at densities up to 18.0-ppg
- Easy to pump using only the rig pumps
- Can be pumped through well bore tools
- No spacer is required
- Not affected by temperature, activator and retarder formulations or pH
- Mixes easily in fresh drill water, seawater or base oil
- Environmentally acceptable (complies with LC50 requirements) Contaminant friendly to both water base and non-aqueous fluids
- can be used up to 10-ppb in the whole circulation system for seepage loss control
- Temperature stable up to 450°F

Spot and squeeze the **Form-A-Squeeze** pill in place using the following procedure:

- Determine as closely as possible location of loss zone.
- Calculate volume of the slurry to cover at least 50% excess above the loss zone.
- Place bottom of drill pipe or bit at depth that will allow an equivalent open well bore volume to remain across the loss zone
- Spot the pill and pull up slowly 90-ft of pipe or into the last casing.
- Close the annular preventer and apply gentle squeeze pressure of 100 to 300-psi or to a pressure that will provide the equivalent of the maximum anticipated mud weight required for the interval.
- Use the cementing pump to get the best control on the squeeze.
- Squeeze at 0.5 bpm.
- Monitor the squeeze pressure while pumping. When the squeeze pressure starts becoming constant with flow rate stop the pump and hold pressure for 3 minutes.
- After 3 minutes start squeezing again at 0.5 bpm. If the pressure becomes constant with flow rate stop the pump and hold for 3 minutes. Continue process

until the pressure increases to the maximum pressure after pumping a minimum volume or you have pumped away the maximum volume determined by pill volume and suspected thief zone.
- Hold the pressure for 30 minutes.
- Break circulation slowly with slow pump rates washing to bottom.
- Resume drilling operations.

To insure the success of the **Form-A-Squeeze** pill, the following is recommended:
- Accurately determine the location of loss zone, to increase the chances for a successful plug
- Do not mix a weighted slurry too far in advance as all weighted fluids are subject to settling with time
- For open well bore squeeze do not mix the slurry in whole mud (it has low fluid loss)
- Build squeeze pressure gently to obtain a successful squeeze

The material is packaged in 40 lb sacks with each pallet containing 50 sacks. This is enough material to build a 25 bbl pill.

Besides the following mixing table, the M-I SWACO FASqueeze program may be used to develop a specific application.

FORM-A-SQUEEZE MIXING CHART FOR ONE BARRELL

Weight (ppg)	Water(bbls)	FORM-A-SQUEEZE, 40 lb sacks	Barite, 100 lb sacks
9	0.88	1.76	0
10	0.85	1.7	0.55
11	0.81	1.63	1.12
12	0.78	1.56	1.69
13	0.75	1.49	2.25
14	0.71	1.42	2.82
15	0.68	1.36	3.38
16	0.64	1.29	3.95
17	0.61	1.22	4.52
18	0.58	1.15	5.08

*Calculations are based on 80 lb FORM-A-SQUEEZE per bbl of base fluid,
SG Barite = 4.2 and SG FORM-A-SQUEEZE = 1.7

APPENDIX 8 - FORM-A-SET AK:

SYSTEM DESCRIPTION

FORM-A-SET AK is a special blend of polymers and fibrous materials designed to plug matrix and fractured zones. When added with DUO-VIS® and activated with a combination of **FORM-A-SET XL™**, time and temperature, **FORM-A-SET AK** produces a firm, rubbery, ductile plug that effectively prevents loss of fluid to the formation. The lost circulation material in the **FORM-A-SET AK** package comprises specially sized and concentrated fibrous cellulose containing a mixture of **fine particle sizes to plug deep fractures, faults, and vugular formations.**

Applications

The FORM-A-SET AK plug can be mixed in freshwater, seawater or saltwater up to saturation. FORM-A-SET AK can be used in any application where a squeeze plug is beneficial and a smaller particle-size distribution of bridging material is desired. This enhances the ability of the material to penetrate a porous or fractured zone.

FORM-A-SET AK is a variation of **FORM-A-SET**. The cross-linking agent for **FORM-A-SET AK** is packaged separately. Thus, the plug without cross-linking agent can be mixed and stored on location as a contingency.

Once losses are encountered, the plug is activated by adding **FORM-A-SET XL** (see enclosed tables for mixing concentration), mixed for five minutes and then **FORM-A-SET AK** is spotted in the loss zone.

FORM-A-SET AK can be used to stop losses occurring with any water, oil or synthetic-base fluid system.

Retarder/Accelerator

Two products are available to help control the setting times of the material: **FORM-A-SET RET** and **FORM-A-SET ACC**.

FORM-A-SET RET, a retarder, is designed for situations requiring longer setting or pumping times and higher squeeze temperatures. **FORM-A-SET ACC** (accelerator) is engineered for situations where set conditions are faster or lower water temperatures slow the cross-linking process.

FORM-A-SET RET should be used with all applications above 100°F. A retarder is required when BHCT and pumping times increase. **The retarder is added to the water prior to the addition of FORM-A-SET AK material**. As a guideline, the typical concentration of retarder is presented in the following table:

Well Bore Temperature		FORM-A-SET RET (lb per bbl of mix water)	
°F	°C	lb/bbl	kg/m³
Up to 100	Up to 37.7	---	---
100-120	37.7 – 48.9	4	11.4
120-150	48.9 – 65.6	6	17.1
150-200	65.6 – 93.3	10	28.5
200-250	93.3 - 121	16	45.6

Note that the FORM-A-SET RET concentration should be proportioned to the water volume. To ensure the time and temperature will not cause the slurry to cross-link prematurely, it is important to pilot test for sufficient retarder concentration.

The **FORM-A-SET** ACC should be used to speed up the setting time of the slurry. It is used when ambient temperatures or make-up water are below 60°F. To avoid over-treatment, caution must be exercised when adding the accelerator. In colder conditions, **suggested concentration of FORM-A-SET ACC is 0.2 lb/bbl proportioned to the water volume.** To ensure full polymer hydration, the **FORM-A-SET ACC should be added after the dry material has been mixed.** This procedure will allow the dry material to blend thoroughly. Afterwards, the **FORM-A-SET** ACC can be added to the slurry to guarantee it is well dispersed. It is suggested that the accelerator be diluted in 5 to 10 gallons of water before adding to the **FORM-A-SET AK** slurry.

UNWEIGHTED SLURRIES MIXING & PUMPING INSTRUCTIONS

To mix an unweighted pill of **FORM-A-SET AK**, use a clean mud pit or recirculating mixer.

- Add the required amount of retarder to 1 bbl of water before mixing any polymers
- Add 1.5 lbs/bbl **DUO-VIS**
- Add 25.0 ppb **FORM-A-SET AK**
- Add 1.5 lbs/bbl **DUO-VIS**

Note: The defoamer may be added at any time air entrapment is observed. Use only alcohol-base defoamers such as **DEFOAM A**.

Defoamers containing stearate or glycol might cause changes in the cross-linking mechanism.

Use approximately 20 to 30 bbl of viscous water or mud as spacers in front of and behind the pill. The preferred spacer is 3 ppb **DUO-VIS** in water.

Once losses are encountered add 5 lb/bbl of FORM-A-SET XL to the pill and mix thoroughly for approximately 5 minutes.

Place the bit across the loss zone. Pump the pill to the bit as fast as possible and continue pumping the pill until the whole pill has cleared the drill string. Even if losses have stopped *DO NOT SHUT DOWN PUMPING WHILE THE PILL IS IN THE DRILLSTRING.* It is important not to leave any pill in the pipe. Watch for any sign of the pill reaching the loss zone, such as a pressure increase or improved return flow.

To begin squeezing, pull above the pill height. Close the annular preventer and begin applying pressure. If pressure is noted, hold for at least three hours to obtain a firm set of the pill. Allow about four hours for the pill to obtain maximum strength.

Total time for the job, including blending, pumping and squeezing is about five hours.

WEIGHTED SLURRIES MIXING & PUMPING INSTRUCTIONS

The following procedure should be followed to mix **FORM-A-SET AK** slurries heavier than freshwater.

Mixing order should be:

1. Add the retarder before the **FORM-A-SET AK**. **The retarder concentration should be proportioned to the water volume.**
2. Add one-half of the **DUO-VIS**.
3. Add one-half the **FORM-A-SET AK** material.
4. Add the barite.
5. Add the remaining **FORM-A-SET AK**.
6. Add the remaining **DUO-VIS**.
7. If needed, add the accelerator concentration in proportion to the water volume.

Once losses are encountered add FORM-A-SET XL to the pill (see chart) and mix thoroughly for approximately 5 minutes.

Form-A-Set AK mixing example

Objective: To formulate a **FORM-A-SET AK** pill for 200°F formation temperature, 15.5 ppg density and pumping time averaging 90 minutes

From the **FORM-A-SET RET** table can be seen that for the formation temperature of 200 °F the retarder concentration should be 10 ppb. From the tables above the formulation and mixing order is as follows:

1. Water: 0.682 bbl
2. FORM-A-SET RET: 10 ppb proportioned to water volume (10 lb of Retarder per bbl of water X 0.685 bbl water = 6.85 ppb mixing concentration for final barrel)
3. DUO-VIS: 0.225 ppb (half of the total required concentration)
4. FORM-A-SET AK: 8.56 ppb ppg (half of the total required concentration)
5. M-I Bar: 393.92 ppb
6. FORM-A-SET AK: 8.56 ppb (the second half of the total required concentration)
7. DUO-VIS: 0.225 (the second half of the total required concentration)
8. FORM-A-SET XL: 3.25 ppb

Weighted slurry - Product concentration for 1 final bbl:

Density lb/gal	Water bbl	DUO-VIS lb/bbl	FORM-A-SET AK lb/bbl	FORM-A-SET XL lb/bbl	M-I BAR lb/bbl
8.36	.931	2.79	23.37	5.00	0.00
8.5	.926	2.78	23.25	5.00	7.87
9.0	.908	2.73	22.81	4.75	35.44
9.5	.891	2.67	22.37	4.75	63.02
10.0	.874	2.62	21.94	4.50	90.59
10.5	.856	2.57	21.50	4.50	118.17
11.0	.839	2.1	21.06	4.25	145.74
11.5	.821	2.05	20.62	4.25	173.32
12.0	.804	1.61	20.18	4.00	200.89
12.5	.786	1.57	19.75	4.00	228.47
13.0	.769	1.15	19.31	3.75	256.04
13.5	.751	1.13	18.87	3.75	283.62
14.0	.734	0.73	18.43	3.5	311.20
14.5	.717	0.72	17.99	3.5	338.77
15.0	.699	0.52	17.56	3.25	366.35
15.5	.682	0.51	17.12	3.25	393.92
16.0	.664	0.33	16.68	3	421.50

Advantages

- FORM-A-SET AK **contains only the polymer and lost circulation material, therefore it may be mixed on location and stored before the anticipated losses are encountered.**
- Owing to its increased polymer loading and the smaller size of the fibrous material, the **FORM-A-SET AK** has a much firmer set than the conventional **FORM-A-SET**.
- Because of the firmer set, **FORM-A-SET AK** has a wide range of applications. These applications range from partial losses (10-100 bbl/hr) to total losses. Furthermore, the material can be used in both water and gas shutoff in non-productive zones, and may be used for gravel consolidation.
- Extended times in the wellbore will not cause a **FORM-A-SET AK** plug to degrade

Limitations

- ***Caution should be exercised when it is used in or near the production zone.***
- Pilot testing for thermal stability is recommended when temperatures exceed 250°F.
- When premixing the pill, include 0.2 lb/bbl of **X-Cide 102** (25% gluteraldehyde biocide) for all plugs. If **X-Cide 102** is not available, pilot tests should be run with the locally available biocides.

APPENDIX 9

LOCK-OUT-TAG-OUT:

LOTO procedure for WSM-03

1. Dryer may need to be cleaned out as often as every ten minutes to as little as once a 12 hour tour. This all depends of size of well bore, ROP, and formation we are drilling through. Dryer needs to be cleaned when amp meter is reading a steady 25 or as service technician believes it needs to be cleaned. Try to clean dryer out when making connection so the smallest amount of cutting go overboard. This is not always made possible but is attempted as much as can be.

2. Before every tour each technician will fill out a isolation permit for their tour. Also a daily log per tour will be kept when it was locked out and cleaned. It will have the technicians name, date, and time. At end of tour one will print out and attached to the permit to be turned in for tracking the times and duration of LOTO.

    - Determine when dryer needs to be cleaned
    - When dryer reaches a predetermined amp reading.
        i. Divert cutting overboard
        ii. Press off button on dryer.
        iii. Let dryer come to complete stop before disengaging oiler
        iv. Turn off oiler until light turns red
        v. Turn off maintenance breaker.
        vi. Put lock on maintenance breaker LOTO cover.
        vii. Attempt to start oiler.
            1. If oiler light turns yellow check maintenance breaker.
            2. If oiler light stays red go to next step
        viii. Attempt to start dryer by pressing start switch.
            1. If dryer starts check maintenance breaker and oiler switches.
            2. If dryer does not start proceed to next step.
        ix. Proceed to clean out dryer.
            1. See JSA and/or THINK plan and modify as needed

    - Reenergizing dryer when cleaning is complete
        - Make sure all doors are closed properly
        - Take lock off maintenance breaker and energize.

    - Start dryer
        - Record time that dryer was reenergized
        - Divert cutting to dryer
        - Observe to make sure cuttings are discharging properly overboard

3. This procedure is strictly to be used while drilling to clean out solids build-up in dryer. Any other maintenance or repairs will follow Transoceans LOTO protocol.
4. See Transocean Energy Isolation Certificate following page.

Transocean

ENERGY ISOLATION CERTIFICATE

START TO BE ACCOUNTABLE

Isolation Certificate No. [illegible]

1.0 WORK DETAILS

1.1	Work Location:
1.2	Work Description:
1.3	Equipment to be isolated:

2.0 PRECAUTIONS TAKEN

2.1 ELECTRICAL ISOLATION

Fuses Withdrawn		Location	Breaker #	Action		Padlock No.	Tagged Out	
Number	Amps							
				OPEN	LOCK		YES	NO
				OPEN	LOCK		YES	NO
				OPEN	LOCK		YES	NO

Other Precautions Taken:

I hereby confirm the above isolations and precautions have been taken, the equipment has been proven de-energized by electrical test and all concerned / affected individuals have been adequately informed.

Name of competent person performing isolation: .... Signed: ....
Date: .... Time: ....

2.2 OTHER TYPES OF ISOLATION

Control Mechanism	Location	Inlet Outlet Drain			Lines Blanked		Valves OPEN CLOSED		Padlock No.	Tagged Out	
		I	O	D	YES	NO	OPEN	CLOSED		YES	NO
		I	O	D	YES	NO	OPEN	CLOSED		YES	NO
		I	O	D	YES	NO	OPEN	CLOSED		YES	NO

Other Precautions Taken:

I hereby confirm the above isolations and precautions have been taken, the equipment has been proven isolated by test and all concerned / affected individuals have been adequately informed.

Name of competent person performing isolation: .... Signed: ....
Date: .... Time: ....

Name of Responsible Person authorizing isolation: ....
Signed: .... Date: .... Time: ....

3.0 RECEIPT OF CERTIFICATE BY PERSON IN CHARGE OF WORK

I acknowledge receipt of a copy of this certificate and understand that the equipment has been isolated and is safe to work on. I have personally checked that the correct equipment has been isolated.

a) Signed: .... Person in charge of work Time: .... Date: ....
b) Signed: .... Person in charge of work Time: .... Date: ....
c) Signed: .... Person in charge of work Time: .... Date: ....

Handover as required: If work is continuing after shift change, isolation must be referenced in shift handover report to relief.

4.0 COMPLETION OF THE WORK

I hereby confirm that the work detailed in section 1 above is completed, the personnel and equipment withdrawn and the isolation may now be removed by a competent person responsible for the de-isolation.

a) Signed: .... Person in charge of work Time: .... Date: ....

5.0 CONFIRMATION OF DE-ISOLATION

I hereby confirm that the isolations detailed in section 2 have been removed and the system re-energized.

a) Signed: .... Competent Person Time: .... Date: ....
b) Signed: .... Competent Person Time: .... Date: ....

6.0 LONG TERM ISOLATION

I hereby confirm that the task detailed in section 1 above is not completed and the equipment has been entered as a "Long Term Isolation". I have placed the equipment isolation keys and a copy of this certificate in the "Long Term Isolation Box".

a) Signed: .... Person in charge of work Time: .... Date: ....
b) Verified By: .... Responsible person Time: .... Date: ....

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Customer-focused, solutions-driven

This suggested program is advisory only and may be rejected in the sole discretion of any and all parties receiving it. In addition all parties receiving this program recognize, agree, and acknowledge that M-I SWACO has no care, custody or control of the well, the drilling equipment at the well, nor the premises about the well. Also, there are obviously many conditions within and associated with a well of which M-I SWACO can have no knowledge and over which it does not and cannot have control. Therefore, M-I SWACO shall not be liable for the failure of any equipment to perform in a particular way or the failure to obtain any particular results from carrying out this program by any party receiving it. Furthermore, the owner and operator of the well and the drilling contractor in consideration of the recommendations contained in this suggested program agree to indemnify and save M-I SWACO harmless from all claims and costs for loss, damage or injury to persons or property including, without limitations: subsurface damage, subsurface trespass or injury to the well or reservoir allegedly caused by M-I SWACO operations or reliance by anyone upon this program unless such personal injuries or damage shall be caused by the willful misconduct or gross negligence of M-I SWACO.