Section 2 VIETNAM APPROVED PROCEDURES

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2.1 HTHP PROCEDURES

This procedure is to be used in conjunction with Rig Interface Documentation and BP Well Control Manual.

INTRODUCTION

General

An HTHP well is customarily defined as a well with a maximum WHP over 10,000 psi and/or BHST over 150o C (300F).

These separate HTHP guidelines have been prepared to implement lessons learned from experience on other HTHP wells and to be used in conjunction with the HTHP Well Control Manual (Volume 3) and any rig interface manual.

It is essential that all key personnel are fully familiar with the content of these guidelines prior to drilling out of the 13 3/8" casing when HTHP conditions are anticipated.

All requirements listed herein are applicable from the time the pressure transition zone is encountered to TD of the well.

Deviations

Any deviations from the HTHP operational guidelines shall be approved by the Drilling Superintendent.

SAFETY AND COMMUNICATION

In order to drill this well in a safe and efficient manner, it is of vital importance that the following basic rules are followed:-

Discussion and Coordination of plans

Each morning, prior to report time, a meeting will be held with leading personnel involved in the drilling operation.

A review of the last 24 hours will be made and the plans will be updated and changed according to the situation in the well. Written plans will be discussed and distributed.

It is important to take the time needed and do the right thing in case an abnormal situation should occur. The situation must be thoroughly evaluated before proceeding into a possible hazardous situation.
Checklists

Specific checklists should be incorporated into rigsite procedures to a wide extent in all operations. These will be drawn up by the Rig Representative.

Safety Meetings

Safety meetings will be held with the drill crew and service company personnel prior to important and critical jobs in order to focus on safety, equipment and procedures. The captain, driller, tool pusher, mud engineer and the BP Rep will attend and contribute to these meetings in order to motivate the crew. The safety meeting will focus on teamwork, what signs to look for and to discuss the procedures to be followed should these signs occur.

Communication and Handover

Good communication is of vital importance at all levels and especially between the driller, mud loggers, shale shaker room and pump room in order to keep good control of volumes, weights etc.

It is very important to have good handover meetings when personnel are changed or relieved.

Drillers should routinely pass through the mud logging unit on the way to rig floor at start of every shift.

Note:

Do not forget to watch the ongoing operation during the handover.

WELL CONTROL

Pore pressure prediction whilst drilling

Formation pressure increase up to 15 psi/m has been experienced on wells drilled in block 05.2 in Vietnam. This challenging environment requires thorough understanding and full attention to the well signals at all times.

Commitment to drilling close to balance is considered crucial to enable the well signals to be transmitted and interpreted. Correct interpretation and prediction is the key to optimum casing seat selection and correct mudweight determination which in turn will lead to safe drilling without well control incidents in the exploration well theatre.
Drilling operations procedure

The procedure included in this manual for drilling in pressure ramps must be adhered to.

This procedure may be modified in the future as a greater understanding of the pressure regime is attained. This may negate the requirement to drill close to balance.

Kick Tolerance

Kick tolerance will be calculated and reported daily as per procedure.

The DM shall be informed when the Kick Tolerance falls below 50 bbl. Kick-Tolerance below 25 bbl requires dispensation from Drilling Policy, approved by the required Technical Authority.

Drilling breaks and flow checking

- Stop drilling immediately when a drilling break occurs. (Do not attempt to drill the stand down if close to connection.)
- All drilling breaks shall be flowchecked for at least 15 min.
- Flowcheck prior to connections when drilling in the high pressure transition zone. The ECD-effect is significant and can mask a static underbalanced situation.
- If the hole conditions permit, shut in the well immediately if a significant drilling break (more than 100% increase in ROP) occurs. Check for pressure build-up. Open well and circulate bottoms up before drilling ahead.
- If in any doubt about a flowcheck, circulate bottoms up prior to drilling ahead. Minor influx volumes increases considerably up the wellbore. (See gas expansion chart in Appendix B.) If circulating bottoms up, ensure pits are closely monitored and shut in immediately at any sign of gain. Consider tail end of circulation through choke.
- All drilling breaks must be reported to the BP Rep. Record and report the drilling breaks and the results of flow checks on the IADC report and in the daily drilling report.
- When circulating bottoms up, consider flowchecking when 1/3 and/or 2/3 of the length of the well is circulated.
- Always rotate pipe during flowchecking (if hole condition allows).

Kick Handling

The key to a successful kick handling in a HTHP well is to minimize the influx volume and thus limit the surface pressures, volumes and temperatures.

Note:

The surface volume of a 10,000 psi gas kick will expand to 250 times the original influx volume.
In order to obtain the criteria above, bullheading may be used in certain cases. Other operators have used the bullheading technique with success in HTHP wells.

**Note:**

Bullheading is considered as an optional kill method (refer to "Bullheading" and BP Well Control Manual for procedures).

- If a kick is taken, the pressure and volumes of gas which will be seen at surface should be predetermined. Pump rates with gas to choke should be determined to ensure that gas handling capability of the "Poor-Boy" degasser is not exceeded.
- To minimize a influx volume the drillers shall at all times know the height to pull up to before closing the annular preventer and be able to close the UPR below a tooljoint. The following procedure should be adhered to:-

  1. Pick up off bottom to a predetermined height.
  2. Stop rotating.
  3. Stop mud pumps.
  4. Close Upper Annular Preventer. Be prepared to close UPR if SICP exceeds 2500 psi.
  5. Reciprocate pipe one single every 15 min. to ensure pipe is free. If sticking tendency is experienced, rotate and slowly reciprocate pipe on one single whilst killing the well. Do not strip tooljoints through the bag. Do not rotate the pipe without reciprocation as the pipe might be severed. Adjust bag closing pressure to a minimum if the pipe is rotated. Proceed according to BP Well Control Manual.

- If no shut-in pressure is observed, check for flow through choke manifold for 15 minutes, open the BOP and circulate bottoms up. Consider to circulate the last 1/3 of the volume through the choke manifold.

**Poor-Boy Degasser overloading**

The "Poor-Boy" degasser pressure must be monitored closely. The maximum operating pressure of the "Poor-Boy" degasser is dictated by the hydrostatic pressure of the fluid in the U-tube seal. The degasser gauge must be visible to the choke operator.

If overloading of "Poor-Boy"/ventline systems occurs, the welltest gasline will be used to divert the flow from choke manifold to burner booms. This means that the well test line from the low pressure side of the rig choke manifold will be lined up directly to the burner booms.

A HP Lines Schematic diagram showing correct line-up must be prepared in advance to ensure the gas is diverted correctly.
Temperature monitoring

The temperature sensors upstream of the choke must be monitored to control the temperature. Slow down the pump rate if the temperature is approaching 80°C.

The temperature downstream of the choke can be used to decide if temperature is in the hydrate formation area or if the lower limit of the design criteria for the choke manifold is approached.

Positioning of well test burner booms

Prior to drilling into the high pressure transition zone the burner booms must be in well test position ready to use.

Operating procedure for well control valves

Well control system valves should, if possible, be operated with no mud flowing through and/or without pressure. The reason being that heavy mud is very abrasive.

To prevent washing out valves when closing them the choke should always be closed first followed by the valve immediately upstream. Should this valve fail, then close the next upstream valve. In all cases, the valve closest to the BOP shall be the last one to close.

Hydrate Prevention

Methanol will be injected upstream of the rig choke manifold prior to gas entering while circulating out an influx. Monitor the temperature and pressure gauges downstream of the choke in order to detect hydrate formation.

Note:

Keep a stock of both methanol and monoethylene glycol on board the rig.

Drill string blowout prevention

- A drill string kelly cock shall always be easy accessible on the drill floor. The kelly cock shall be available for all drill string connections including the BHA. The kelly cock shall be of a full bore design to allow dropping of the dart.
- A dart sub shall always be a part of the BHA (installed one single above drill collars). Ensure that the dart passes through the kelly cock and the HWDP.
- If the drillstring for any reason should be left open, a full bore valve must be installed on the drillstring in the rotary table.
- A kick joint will be available. The kick joint will be used if a kick with SIDP above 2000 psi is taken and/or if bad weather during well killing.
- Take SCR's both through TDS and through chicksans/kick joint with the cement unit to determine the difference in pressure drop prior to drilling into the pressure ramp and when a significant increase in mudweight has taken place. Consider to
take returns through both kill and choke lines to reduce friction losses if there is a limited window between the pore- and fracture pressure.

- When doing wireline work inside drillstring (shooting off stuck drillstring, backing off etc.), use pre-determined rigup.

**Hang-off / WOW**

- Pull into casing and hang off drillstring in wellhead. Increase mudweight to add a riser margin in case disconnect is required.
- Displace the drillstring to a more viscous mud in order to reduce the possibility of plugging due to barite settling.
- Check for pressure below S/R and MPR after reconnecting the LMRP.
- If pressure, open MPR and circulate mud to check for gas and to displace out water in kill and choke lines. If no pressure, reconnect landing string and circulate bottoms up.
- If still pressure, close MPR and circulate down drillstring with shear rams closed and with returns through chokeline.

**Bullheading**

Bullheading is **NOT** the primary well control method.

A maximum allowable surface injection pressure based on the LOT and eventual FIT and the present mudweight will be decided in advance. Therefore, the MAASP must be updated every time the mudweight is changed.

Bullheading a kick will be considered when the following conditions are encountered:

- The influx gradient is determined to be gas.
- The kick size is larger than 25 bbl, or considered too large to be safely circulated to surface.
- Returns are lost when starting to circulate out the kick if confident that the losses are into the kicking zone.
- When the drillstring is out of the hole.
- The kick is caused by swabbing when POOH (evaluate each situation carefully and consider stripping).
- Bullheading can also be used if it is apparent that the surface pressure (or H2S presence) would pose a serious risk to the rig and its equipment during normal killing operations.

**Drills**

- For BOP drills refer to BP Well Control Manual. A part of the drill is to check the various pressure gauges and any discrepancy between them. The discrepancy to be posted in the driller's house.
A strip drill to be included in the D5 drill.

- Kick drills (installing kelly cock on drill string) will be performed frequently to ensure crew efficiency.

Note:

All drills shall be reported in the IADC report and in the daily drilling report.

DRILLING

BHA

- Optimize the BHA in order to reduce the ECD. Consider to use more 5" HWDP and less drill collars to reduce the possibility of fracturing potential weak zones during drilling and circulating. Use 2 stabilizers only (60' and 90').
- When selecting bit nozzles keep in mind that plugging of the drill string should be avoided when pumping LCM-pills.
- A pressure relief sub shall be included in the BHA whenever a MWD-tool is used.
- Consider to install a circulating sub in the BHA, but be aware of the possibility for a washout.

Directional Surveying

Single shot surveys shall not be retrieved in open hole. Drop single shot surveys after the check/short trip.

LCM pills and barite plugs

Procedures for how to mix and set LCM pills and barite plugs as per issued approved procedures.

Drilling parameters

- Drilling parameters, including Dxp and gas measurements will be recorded on charts. Charts are to be evaluated continuously. Any significant change in trends must be reported immediately to the BP Rep.
- The drilling parameters will be continuously monitored by both the Mudlogging system and Rig's system. Any discrepancies between the two systems will be investigated.

Float in drill string

The inclusion of a float valve is not recommended in the BP Well Control Manual but is in the Statoil HTHP procedures. This issue should be addressed fully.
Kill mud

Consider to have one mud tank already weighted up to kill mudweight when approaching any reservoir section. This will speed up the killing operation.

Volume control

It is imperative when drilling HTHP wells to have full volume control at all times. Minimize the active pit surface area and avoid activities that will influence on the volume of the active pit while drilling. The following basic rules to be followed:

- Do not transfer mud or mix into active system (unless in critical situations).
- Additions to the active mud system, dumping of shaker box and sandtraps will only be made by the mud engineer.
- The BP Rep, driller and mudloggers must be informed in advance of any transfer to or from the active volume.
- After the shakerbox or sandtraps are dumped, the tanks must be filled up and volumes stabilized before drilling is continued.
- Stop drilling while circulating to new mudweight in the transition zone if the pressure increase trend is uncertain.

Connections

Always flowcheck prior to connections whilst drilling through any pressure ramp. All connections to be made on triptank.

TRIPPING

Responsibility

The BP Rep will always be present on the drill floor when tripping in open hole.

Tripping Speed

Tripping speeds must be controlled. The surge/swab effect can be considerable in deep wells. Perform a calculation on surge and swab before each trip based on actual/known mud parameters and hole/string configurations. Also use the calculated tripping speed inside casing.

Trip Sheet

The trip sheet shall be filled in by both the A/D and the Mud Logger. Actual volumes to be checked against theoretical volumes on all trips. The trip sheets shall be delivered to BP Rep after each trip.
Circulation during tripping

When RIH circulate for 15 minutes or string volume after filling the drill string. Consider to circulate longer to reduce the temperature of the MWD-tool, if used.

- Consider to circulate bottoms up at the casing shoe when RIH in order to reduce gel strength and surge pressures. As a minimum circulate string volume to remove air.
- For pore pressure evaluation, consider to circulate bottoms up prior to start drilling after a round trip.
- Rotate the drill string prior to starting pumps and move drill string upwards when breaking circulation in order to avoid fracturing the formation.
- Make a 5 stand short trip (swab test) with pumps off prior to circulating bottoms up before tripping out of the hole.
- Do not pump slugs before making short trips. Slug pipe only when inside casing.
- When POOH, perform a flowcheck at bottom, when inside the casing shoe and before pulling the BHA through the BOP.
- Either when pumping out or pulling a wet string, take returns from the mud bucket into the trip tank. The hole will then be filled according to steel displacement.

Trip Margin

Dependent of the actual well situation (conditions of drilling fluid, mudweight, riser margin, pore pressure, fracture gradient etc.) evaluate the need for an extra safety margin during tripping out of the hole.

The trip margin can either be increasing the density of the full active volume or by pumping a heavy pill inside casing. Circulate to initial mudweight before drilling is continued.

Stripping

A detailed stripping procedure must be created by the tool pusher / driller prior to drilling out of the 13 3/8" shoe. The procedure shall be made as a part of the D5 drill.

Influx during tripping

If the well starts to flow during tripping, either proceed with stripping operation immediately or bullhead and then start stripping operation.

Note:

Do not RIH without the necessary precautions while the well is flowing.
Slugs

Slugs inside DP will act to reduce the SIDPP if a kick is taken. The drillers must always know where the top of the mud column inside DP is and the effect the slug has on DP shut-in pressure.

DRILLING FLUIDS

Mud scale calibration

Operating with high mud weights put special focusing on mud scale calibration. The only mud scale to be used is the pressurized mud scale. This has to be calibrated for mudweights in excess of 2.0 SG. A minimum of 3 calibrated mud scales must be available at all times.

Make sure that the mud scales in both the shaker room and the pump room are reading the same after the calibration/check.

Note:

The mud engineer is responsible for checking and calibrating the mud scales.

Recording mud weights and viscosity

The mudweight and viscosity shall be checked every 15 minutes in the pump room and at the shakers and more often if deemed necessary. All readings to be recorded and given to BP Rep at the end of each tour.

Recording cuttings return

A device for measuring cuttings return should be made. Record cuttings return frequently and plot actual returns vs. theoretical. The result will assess hole cleaning and possible wellbore washouts.

Water usage on rig floor and shale shakers

Reduce the water usage on rig floor and shale shakers to a minimum. Small amounts of water will contaminate the mud and subsequently reduce the mud weight.

Bulk barite supply

Ensure that the bulk barite system is operational at all times. Fluff the tanks and check barite transfer. Keep the surge tank full.

Ensure sufficient barite supply by fully utilizing the workboat capacities at all times.
INSPECTION AND MAINTENANCE

Inspection of the drill string

Prior to drilling this well the whole drill string will be inspected (including all subs and x-overs). All drill string rental equipment will be inspected and the inspection report will be enclosed.

Maintenance

All planned rig maintenance/repair to be done with the bit at casing shoe whilst running in the hole (not whilst POOH). In addition to the standard maintenance programme, the following should be adhered to:-

- Change out the wash pipe and the saver sub prior to drilling out of all casing shoes below the 20”.
- The drill pipe connections must be cleaned and visually inspected when pulling wet. Solids build-up on threads is a common problem when pulling wet using high mudweights.
- Alternate standbreaks for each trip to maintain a clean and freshly doped connection thus preventing high breakout torque.
- Stand connections in the BHA must be visually inspected on each trip. Service break and inspect (or change out) the whole BHA after approximately 120 rotating hours in order to detect cracks etc. An inspector must be on the rig for this purpose.
- All mud pump maintenance planned in the course of drilling this well must be done prior to spud to ensure maximum reliability. 5 1/2” piston/liners to be installed prior to drilling out of 13 3/8” shoe.
- Well control equipment
  1. Flush through surface well control system once every 12th hour.
  2. Keep treated mud in K/C-lines and circulate every 6th hour in order to avoid plugging.
  3. Keep full volume control of the active mud system when flushing BOP equipment.
  4. Keep the "Poor-Boy" degasser liquid seal full with mud and flush through every 12th hour. Check drain valve for plugging.

Note:

Keep an extra stock of the various K/L valves and repair kits.

Testing and calibration of gauges, detectors etc.

A programme for control, maintenance and calibration of sensors shall be prepared.
- All flowmeters, gas detectors, pit level recorders, pressure and temperature sensors are to be checked and calibrated prior to drilling out of all casing shoes below the 20".
- Rig Contractor, Mudloggers and Cementers are to make sure that their sensors and instruments are working correct at all times.

**Casing Wear**

- Ditch magnets will be installed in the flowline in order to monitor casing wear. Inspect magnets and weigh the steel recovery every 20 rotating hours. Plot recovery on graph.
- Examine wear on wear bushing each time it is pulled when the BOP is pressure tested. Also consider to inspect wearbusing in WOW periods if conditions permit.
- Pressure test the upper 5 joints of 9 5/8" casing with a cup tester if there are signs of wear beyond normal on the wear bushing or the ditch magnets. The applied pressure will be determined based on the pore pressure encountered. Consider to space out and hang off in the wellhead with the hang-off tool. (Do not suspend load to blocks). Casing patching equipment and procedures must be readily available in case the casing does burst during this test.
2.2 SHALLOW GAS PROCEDURES

GENERAL

The following procedures are to be followed when the potential exists for drilling into a shallow gas feature.

In order to be prepared to handle such an emergency, all personnel are to be informed in daily safety meetings of the ongoing potential for shallow gas. Hand held radios will be given to all personnel involved in the shallow gas procedures.

A special station bill is to be prepared by the Barge master and Toolpusher. Shallow gas and associated drills (Abandon, Muster etc.) are to be carried out prior to spud and daily while drilling surface hole.

All life-saving equipment must be certified and be in full ready condition.

All personnel who have been given a specific task in this procedure are to make sure that they know their position and the tasks given to them.

PRECAUTIONS BEFORE DRILLING

Cable Scope

There will be enough cable in the lockers to allow deployment of 300m of cable in any one direction.

Rig Heading

West Delta will head towards the prevailing current and wind.

Winch-off Drill

Once anchored on location, a full winch off drill will be conducted with all the crew participating. Cable is to be marked by paint for re-establishing location. Winch off direction will be towards the prevailing weather.

Kill Mud

At least five hundred barrels of kill mud weighted at 1.20sg will be kept in reserve. This is to be prepared prior to spud.

Pump Liners

Use largest liners possible.

Gas Detection Systems
Test all the gas detection systems on the rig. This should include the mud logging companies. Record that they have been tested and are operational. BP Representative to witness.

**Air Inlets**

Ensure that the main rig engine air inlets shut-off devices are operational. Record that they have been tested and are operational. BP Representative to witness.

**Water Deluge Systems**

Check that all water deluge systems in critical areas are operational. Record that they have been tested and are operational. BP Representative to witness.

**Cement Unit**

Check that the cement unit is fully operable. Mix a 50 bbl slurry and pump it overboard. BP Representative to witness.

**Evacuation Plan**

Depending on the risk of shallow gas at the well location, the need for a "Quick Evacuation Plan" should be considered at the planning stage.

If it is deemed to be required such a "Quick Evacuation Plan" should be prepared. This plan should bear in mind that gas may be on surface during evacuation. A minimum manning level should be decided on prior to spud and only essential crew remain onboard. Captain and BP Representatives responsibility.

Copies of this evacuation plan to be approved by DS/DM. Copies to be sent to HCMC.

**Explosion Meters**

Explosion meters should be available on the rig and used in the event of a gas flow around the rig.

**PRECAUTIONS DURING DRILLING**

**The Anomalies**

All shallow gas anomalies will be identified in the Shallow Gas Assessment together with location and depth.

The personnel involved must be familiar with the risk associated with each anomaly, its depth and whether the anomaly is intersected by the well bore.
Weather Conditions

Consider not starting operations if bad weather is predicted.

Pilot Hole

Given the risk of shallow gas as defined in the Shallow Gas Assessment the need for a pilot hole must be assessed during the planning of the well.

Consideration will be given to drilling the interval containing a shallow gas anomaly during DAYLIGHT HOURS.

The pilot hole shall be drilled with seawater and viscous pills, unless otherwise stated. The BHA for a 8 1/2" pilot hole will be as follows:-

Bit (no nozzles), Bit Sub (with non-ported float valve), 8x6 3/4" DC's, x/o, 1xHWDP, Dart Sub, 11xHWDP.

ROP will be limited to 30 m/hr and flowrate will be kept at or below 450 gpm to minimise hole erosion. This flowrate will be inefficient to clean the well if it washes out and may be increased as required. All flowchecks shall be carried out with the ROV on bottom. See Volume 3. If the well flows see Volume 4 and the decision tree.

The cement unit shall be lined up with seawater while drilling the pilot hole.

Drilling Through a Shallow Gas Anomaly (Risk - Moderate or higher)

If the well bore is to penetrate a shallow gas anomaly with a risk of moderate or higher.

The pilot hole is to be drilled to 10m above the top error bar on the anomaly and the well circulated clean. A Kelly Cock should be installed at this point in case of float valve failure - see Kelly Cock Placement. The open hole will then be displaced to 1.20 sg mud. Drilling shall continue with mud to 5m below lowest error bar of the anomaly. The well will then be flow checked for 15 minutes. If there is no flow seawater will be circulated to 50m above the bit. Again the well shall be flow checked for 15 minutes. If there is no flow the open hole will be displaced back to seawater. The well will again be flow checked for 15 minutes. If the well does not flow drilling shall continue. If the well flows the open hole shall be displaced back to 1.20 sg mud. If the well continues to flow the rig will be winched off location.

With regard to flowchecks. Not only should gas be monitored for but also water flows. If water is seen it could mean that it is being driven by gas. This phenomenon was witnessed in the Gulf of Mexico.

At TD and or prior to any trip the hole will be circulated clean (1.5 x annulus volume) and the well flow checked for 15 minutes. If there is no flow the well shall be circulated to 1.20sg mud.
Observing the Well

All flowchecks will be carried out with the ROV on bottom. The sonar shall be utilised as it is likely to be very 'murky'. A bright spot should be detected if gas passes.

As a minimum the well will be flowchecked at TD of the pilot hole (or 26" hole section, if a pilot hole is not drilled) prior to POOH.

As a minimum a "bubble watch" shall be maintained by personnel in the moonpool. Additional bubble watches can be maintained by the supply vessel and personnel forward and aft of the rig if deemed necessary.

Tripping

Care must be exercised while tripping. The following procedure should be adopted if a shallow gas anomaly has been penetrated by the well bore.

The hole is to be continuously observed by the ROV to check for flow. Particular care will be taken while and after tripping out. To reduce the chance of swabbing the string should be pumped out and the trip rate kept to more than 90 sec/stand. This rate should be confirmed with the mud loggers. There will be observers forward, aft and at the moonpool to watch for gas bubbles.

After tripping one stand past each anomaly, the well will be flow checked for 15 minutes. Trips in the hole should be at a rate which minimises surging.

Kelly Cock Placement

A Kelly Cock will be put in the string while drilling a shallow gas anomaly penetrated by the well bore. This will allow the DP to be shut in should the float fail.

As described above drilling shall stop 10m above the error bar on light green and the well circulated clean. The Kelly Cock will be installed at this point in the tool joint immediately above the rotary table. The next stand should be drilled down.

Consequently the stand just drilled down will have to be pulled back to the rotary, the Kelly Cock removed, the stand replaced and RIH and the Kelly Cock placed on top of the stand with the tool joint at the rotary. The next stand will be attached and drilled down.

Prevent Ignition

Fire hoses are to be positioned on anchor winches and used to avoid sparks while winching off. No Hot Work Permits shall be issued.
Standby Vessel

An anchor handling vessel will be standing-by the rig during the riserless drilling operations. It will maintain a "bubble watch". A towing bridle will be kept ready to be given to the anchor handler with a messenger line attached under the helideck.

Bulk Silos

Bulk Silos will be kept pressurised. BP Representative to witness.

Secure the Rig

All watertight doors will be secured. All hatches and portholes will be closed and dogged down. Cranes will be secured while not in operation. BP Representative to witness.

Air Support

Helicopters shall be on standby in Vung Tau to support any emergency evacuation.

KICK WHILE DRILLING

If gas is detected by the ROV or bubbles are observed around the rig, the control room will raise the GAS ALARM and non-essential personnel will muster to the designated Safe Briefing Area. The captain will ensure that all non-essential ventilation, air conditioning and heating is shut down.

If the well flows, two options exist:-

1. Winch off immediately;
2. Dynamically kill the well;

If the volume of gas discharged from the well is too great and breaking out at surface such that the crew and rig are in danger, winch off immediately - section 6. If the volume of gas discharged is acceptable and there is no breakout at surface and the crew and rig are not in immediate danger, an attempt shall be made to dynamically kill the well.

Dynamic Kill

It should be noted all pilot holes drilled to date have washed out to greater than 22". Thus, the rig must be aware that any dynamic kill may not work. Increase flowrate to 1000 gpm. At the same time the Derrickman will line up the kill mud. All the kill mud will be pumped at 1000 gpm. On completion of pumping the Derrickman will switch the suction to seawater and the well will be observed.

If the well is still flowing after the kill mud has been pumped, seawater will continue to be pumped while preparations are made to winch off the well - See section 6.
If the well has stopped flowing a decision shall be made as to the best way forward when
the well is back under control. Preparations should be made for pumping a cement plug.

**KICK WHILE TRIPPING**

If gas is observed while POOH the string should be run back to bottom and the well
dynamically killed - see section "Kick While Drilling".

If it is impossible to get to bottom due to large volumes of gas being discharged, the rig
will be winched off location - see section "Winching Off The Well".

**WINCHING OFF THE WELL**

If the gas flow remains uncontrolled the rig will be winched off location. This may
require that the drillstring be dropped (every effort should, however, be made to retrieve
the string as it will complicate any further re-entry).

Before dropping the drillstring the kelly cock, if installed, should be closed. If the Kelly
Cock is not installed it may be necessary to drop the dart sub in the event that the float
valve is suspect.

If the Kelly Cock is installed, pick up the string to above the Kelly Cock and close it.
Break the connection above the Kelly Cock, RIH and spin the pipe off.

If no Kelly Cock is installed, pick up one stand. The BP Rep. will determine whether the
Dart should be dropped. If no dart is to be dropped, break the connection at the table, RIH
and spin off.

The guidelines shall be parted by overpulling, if necessary.

The rig will be winched off location in a direction up current and upwind of the gas
plume.

A winch-off plan must be developed for the direction against the prevailing weather and
submitted to the BP Rep for approval prior to spud.

On 06-LT-1XR with the Actinia the winch off plan was as follows;

"Anchor winches 1 & 8 will be left in gear, and fully lined up with water, oil and
compressed air. Anchor winches 4 & 5 will be ready for dynamic release, and fully lined
up with water (for maximum braking), oil and compressed air.

Anchor winch lubricating oil pumps will be started from the Switchgear Room. On
confirmation that the anchor winches have been assigned, the Control Room will put all
switches to the central position."
Anchors 6 & 7 shall be fully slacked off - leaving wire across telephone cable. Simultaneously, the leeward anchors (4 & 5) will be paid out 100m while the windward anchors (1 & 8) will be winched in 100m.

If the operation has to be repeated, anchors 3 may have to be slacked off." During winching operations the chains will be sprayed with water to suppress sparks.

In addition to slacking off the anchor chains, the guidelines will require slackening.

In the event of a blackout the windlasses will be in operable. Thus it is very important that the clutch be disengaged from all windlasses as soon as possible. The chains would be held on the brake. Only as a last resort would all chains be released since this action would cause sparking.

Due to the possibility of blackout etc., all non-essential personnel will be evacuated at the earliest possible moment after observing gas from the well. The "quick evacuation plan" should be followed.

MUSTERING

Mustering will be done at the vessel's Safe Briefing Area.

SHALLOW GAS DUTY ROSTER

- **BP Drilling Representative**
  - In charge of well control.
  - In liaison with Captain determine if partial or total evacuation is required.

- **Toolpusher and Drill Crew**
  - In charge of well control.
  - In charge of dropping the string.
  - In charge of breaking the guidelines.

- **Captain and Marine Crew**
  - In charge of readying the rig to move off location.
  - In charge of making the rig watertight and shutting down non-essential heating, air-conditioning and ventilation.
  - In charge of securing cranes.
  - In charge of ensuring all life saving equipment is operational (including SCBA)
  - In charge of mustering all non-essential personnel.
  - In charge of moving the rig, and maintaining trim while moving.
  - The captain is required to determine whether partial or total evacuation is necessary.
  - In liaison with the BP Representative, determine if partial or total evacuation is required.

- **Medic and Materials man**
  - In charge of mustering personnel in the Safe Briefing Area.
• **Chief Electrician & Chief Engineer**
  o Prepare and assign power from the drill floor to the anchor winches.
  o Assist with winching as required.

• **Crane Operator and Roustabout Crew**
  o Apply water spraying equipment to anchor winches.
  o Prepare personnel basket upwind for evacuation to standby boat.

• **Control Room Operator**
  o Monitor gas levels on rig.
  o Shut down ventilation from Emergency Stop Switch Panel.
  o Maintain the rig's trim while moving off location.

• **Radio Operator**
  o Inform standby boat to head upwind and prepare for evacuation of rig personnel.
  o Initiate Emergency Response Procedures.
2.3 LOST CIRCULATION PROCEDURES

3. A. PREPARATIONS

Post Standing Instructions

Post standing instructions to ensure that the driller is aware of his crews responsibilities in the event of losses. Standing orders should also be prepared for Mud Loggers and the Mud Engineer. These will be specific to each rig, but must include the line up of all surface equipment to allow rapid pumping of mud or seawater to the annulus, and well shut-in procedures and criteria.

Lost Circulation Drills

The BP Representative must hold drills to ensure that each crew reacts correctly when losses are encountered. Mud loggers and the cement and mud engineers should be included in these drills. Response times should be recorded.

Drills should be conducted with each crew to firstly familiarise and then practice their required actions in the event of total losses. They should be made aware of all the potential warning signs. A list of responsibilities should be posted for each member of the team that will be involved in fighting losses.

Pre-drill out meetings

A pre-drill out meeting must be held with all relevant crew. A technical presentation on the various problems and potential solutions should be given to increase all personnel's understanding.

Notify Onshore Personnel

Ensure that the duty personnel, Base Representatives and mud company personnel are aware that the well is approaching the carbonates.

Maintain Chemical stocks

Bulk barite and sacked chemicals must be maintained at a high level at all times. Suggested minimum volumes that the rig needs to be able to build are:-

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional LCM</td>
<td>650 bbls @ 80 ppb</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>100 bbls</td>
</tr>
<tr>
<td>Cement</td>
<td>To capacity</td>
</tr>
<tr>
<td>Visplex</td>
<td>1000 bbls</td>
</tr>
<tr>
<td>Gunk treatments</td>
<td>500 bbls</td>
</tr>
</tbody>
</table>
The following minimum chemical stock is based on Dowell IDF recommendations:

<table>
<thead>
<tr>
<th>Product</th>
<th>Unit</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nut Plug (F)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Nut Plug (M)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Nut Plug (C)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Mica (F)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Mica (M)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Mica (C)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Quikseal (F)</td>
<td>40 lb sack</td>
<td>80</td>
</tr>
<tr>
<td>Quikseal (M)</td>
<td>40 lb sack</td>
<td>80</td>
</tr>
<tr>
<td>Quikseal (C)</td>
<td>40 lb sack</td>
<td>80</td>
</tr>
<tr>
<td>Calcium Carb.(F)</td>
<td>50 kg sack</td>
<td>60</td>
</tr>
<tr>
<td>Calcium Carb. (M)</td>
<td>50 kg sack</td>
<td>60</td>
</tr>
<tr>
<td>Calcium Carb. (C)</td>
<td>50 kg sack</td>
<td>60</td>
</tr>
<tr>
<td>Idvis</td>
<td>25 kg sack</td>
<td>160</td>
</tr>
<tr>
<td>Idpac</td>
<td>25 kg sack</td>
<td>160</td>
</tr>
<tr>
<td>CMC HV</td>
<td>25 kg sack</td>
<td>160</td>
</tr>
<tr>
<td>Bentonite (Wyoming)</td>
<td>100 lb sack</td>
<td>200</td>
</tr>
<tr>
<td>Visplex</td>
<td>25 lb sack</td>
<td>80</td>
</tr>
<tr>
<td>KCl</td>
<td>50 kg sack</td>
<td>400</td>
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<tr>
<td>Calcium chloride</td>
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<tr>
<td>CFCL</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>SM(X)</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Soda Ash</td>
<td>50 kg sack</td>
<td>40</td>
</tr>
<tr>
<td>Caustic Soda</td>
<td>50 kg drum</td>
<td>48</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>50 kg sack</td>
<td>40</td>
</tr>
<tr>
<td>Instavis</td>
<td>25 kg sack</td>
<td>80</td>
</tr>
<tr>
<td>Barite</td>
<td>MT</td>
<td>To capacity</td>
</tr>
<tr>
<td>Bentonite (bulk)</td>
<td>MT</td>
<td>20</td>
</tr>
</tbody>
</table>
3.B. OPERATIONAL PRACTICES

Running LCM in the drilling fluid

With partial losses expected or ongoing, dosing the mud with c. 15 - 20 ppb or so LCM (mica fine is GRE recommendation) is a possible preventative measure. This will require the by-passing of the shakers for prolonged periods. This obviously has an impact on cuttings evaluation if drilling is continued, so when a critical pick is needed such as looking for the top carbonate this technique will have limited value. Coarser screens should be installed, or a thorough programme of sidewall cores could be used as compensation.

Careful consideration should be given to the addition of LCM if any kicks are to be circulated out as this could easily plug the choke. It is expected that any kicks associated with losses will be bullheaded.

Maintain good drilling fluid properties

- Rigs should have upgraded solids control packages on board. This will allow the mud properties to be closely controlled.
- Keep the mud weight as low as is possible to give a satisfactory overbalance and riser margin.
- Maintain gel strengths, yield point and viscosity at the lowest levels that will effectively clean the hole.
- Maintain low MBT levels.
- Keep fluid loss low to prevent excessive filter cake build-up.
- High pH, coupled with low fluid loss may prevent the dissolution of the carbonates, particularly the evaporitic crystals which form in the cavities. Preventing this dissolution will limit the propagation of fractures and losses. The pH should be above 9.5.
- The carbonate (particularly in the Da Nang wells) may contain some carbon dioxide. This should be treated to prevent flocculation.

Minimise surge & swab pressures

- While tripping in, break circulation at the shoe, and every 300m in open hole. Circulate for at least 5 minutes. Bring the pumps up slowly after connections. Rotate the pipe before turning on the pumps.
- While tripping out, pump out for the first few stands/singles off bottom.
- Keep tripping speeds slow (On well 118 - CVX - 1X pipe was pulled as slow as 90 seconds per stand).
- Geoservices must routinely calculate surge pressures for each trip.
- Consider the use of lubricants to reduce drag.

Keep ECD to a minimum

- Reduce restrictions in the annulus (filter cake build up).
- Keep hydraulics at the minimum level required to clean the hole. This can be readily calculated from the DEAP hydraulics programme. Pump occasional hi-vis sweeps if necessary.
- Control ROP to avoid loading the annulus, reduce the length of the exposed loss zone, and if the top of the carbonate kicks, reduced ROP will also help reduce influx size.

**Surface Equipment**

- Remove pump strainers.
- Line up surface pipework so that at least one mud pump can be rapidly switched to seawater.
- Have all surface equipment pressure tested in advance. Also have the ROV/SSTV check the riser for leaks on a daily basis. The normal procedure would be to check for leaks in the surface equipment before assuming that losses were downhole. It is unlikely that there will be time for this, so constant vigilance on the surface equipment is essential.
- Ensure that no mud transfers, additions or dilutions are carried out while drilling proceeds towards or in a loss zone.
- Calibration charts should be drawn up so that the mudloggers know how much mud is discharged by each piece of surface mud cleaning equipment. However, using surface cleaning equipment which may mask slight losses should be avoided. Maintaining constant circulating rates will aid detection of pit level changes.

**Downhole Equipment**

- Remove bit nozzles.
- Minimise the BHA. No stabilisers and only the minimum number of drill collars and heavy weight drillpipe should be run. Restrict angle build by maintaining high RPM and low weight.
- Avoid running tools with limited flow paths or restrictions where possible. This includes core barrels, MWD tools, mud motors, floats and survey rings.
- Do not run drillpipe/casing protectors - these can swell and act like a packer

**Personnel**

- Two Mud Engineers will be on board the rig as drilling nears the carbonates to allow for full 24 hour coverage.
- Two Drilling Engineers will also be on board if necessary.

A demonstration of the effect of sodium silicate and calcium chloride mixing to instantaneously form a precipitate is a powerful reminder to the crews of the dangers of allowing these two reagents to mix inside pipe. A similar demonstration should be made to illustrate the reaction between sodium silicate and cement, the DOB reagents etc.
RFT in Top Carbonate

It is essential to know the pore pressure in the carbonate if it is gas bearing, as precisely the right mud weight must be used for well control and further drilling. The balance is extremely fine between loss and gain, and this was demonstrated vividly on 118 - CVX - 1X. If operationally safe, it is proposed to run an RFT as soon as enough carbonate is penetrated.

Pull Back to Safety

Always pull the drillstring far enough above the loss zone so that all the treatment is out of the pipe before it hits the formation. In this way, any resistance built up as the initial treatment hits the formation need not be broken down by having to apply a squeeze pressure to displace the string.

The string can be pumped out of the well, thereby displacing the treatment while pulling out. Continue pulling to the shoe keeping pipe moving at all times.

Cement should not be pumped if there is doubt about whether the string can be pulled back to the shoe safely.

Warning Signs

- A VSP will be run 50m above the error bar on the top carbonate to better define the depth.
- There is a possibility that seepage losses may occur prior to the major losses.
- It is still essential to monitor for signs of increasing overpressure.

Attack Immediately

Losses should be dealt with as they occur. It is possible to drill ahead with losses, but if the openhole section is too large, then it is difficult to direct the treatment to the place it is needed. Additionally, if a higher pressure zone is penetrated an underground blowout may result.

To permit a treatment as soon as the loss zone is encountered, have a slug pit full of LCM. A minimum of 100 bbls pumpable volume should be available. This should be mixed at the highest concentration the agitators can handle. The recipe for this pill is given in Option 1, page 11.

In order to give some flexibility a 50 bbl DOBG gunk treatment should be prepared in the cement batch tanks. The recipe for this pill is given in Option 6, page 19.

Instant seal preparations should be made if the required personnel are on board.

Have a large volume of reserve mud prepared.
Identify where the Loss Zone is

- If losses first occur while drilling ahead, or are accompanied by a change in torque or a drilling break (including the bit dropping) then the losses are likely to be on bottom.
- If losses occur while tripping or increasing mud weight, then the losses may be off bottom. If necessary a temperature or spinner survey can be run.

Avoid Stuck Pipe

When losses occur, cuttings will settle out around the BHA, and may mechanically stick the pipe. The cuttings will act as a packer, and exacerbate losses below them. Always keep the pipe moving. Where possible, pull to the shoe before attempting a treatment. As a rule, have enough open hole volume below the bit to accommodate the whole treatment.

The reactive clays overlying the formation are likely to become unstable if exposed to uninhibited fluids.

As loss zones may be at low pressure, beware of differential sticking.

If pumping LCM followed by cement, ensure that the LCM is clear of the pipe before pumping cement.

Carry out pilot tests for each treatment.

Well Control

A kick associated with severe or total losses will be bullheaded back to the formation. Influxes from carbonates may contain hydrogen sulphide. Mask up as per hydrogen sulphide procedures if gas from the carbonates is being circulated.

With the annular closed, and losses to a highly permeable gas-bearing formation, the likelihood of gas inversion is high. This effect will cause gas to migrate up the well bore, displacing the mud in the well as it does so into the formation.

If bullheading is used, bullheading rates must never be less than 600 gpm.

If it is necessary to pump seawater (or any fluids of varying density) to the well, ensure that the number of strokes pumped is recorded. It is essential to be able to calculate the height of seawater, and therefore the hydrostatic pressure in the well at all times.

A separate 'best-practice' well control manual dealing with the specific problems associated with well control and total losses is being compiled.

3.C. CHOOSING THE RIGHT TREATMENT
The following listings give the 'first-strike' responses that should be taken when encountering losses. While these should be adhered to initially, specific conditions and the experience gained from previous treatments may mean that there are changes from these procedures.

Any deviations must be discussed with HCMC before proceeding.

Pilot tests should be run with all treatments to ensure compatibility with mud, effectiveness etc.

Quantification of losses

The magnitude of losses is classified as follows:

<table>
<thead>
<tr>
<th>Loss Type</th>
<th>Loss Rate (bbls/hr)</th>
<th>Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seepage</td>
<td>1 to 10</td>
<td>Porous &amp; permeable</td>
</tr>
<tr>
<td>Partial</td>
<td>10 to 50</td>
<td>Unconsolidated sands &amp; gravels; Small open fractures</td>
</tr>
<tr>
<td>Severe</td>
<td>50 to 500</td>
<td>Long sections of unconsolidated sands etc. Fractures</td>
</tr>
<tr>
<td>Total</td>
<td>&gt; 500</td>
<td>Cavernous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Large fractures</td>
</tr>
</tbody>
</table>

Severe or total losses are expected in the carbonate sections of the wells.

Understanding the type of loss is essential in choosing the right type of treatment.

SEEPAGE LOSSES (1 - 10 bbls/hour)

1. Treat active with 15 - 20 ppb Mica (F)
2. Spot 50 bbls LCM pill containing:- (Volume 2, Section 2, Paragraph 3D, Option 1)
   o 15 ppb mica (F)
   o 15 ppb Quikseal (M)
3. Spot larger LCM pill with higher viscosity and higher concentrations (Volume 2, Section 2, Paragraph 3D, Option 1)
4. Proceed to 'Partial losses'

PARTIAL LOSSES (10 - 50 bbls/hour)
1. Spot 50 bbls LCM pill containing:-(Volume 2, Section 2, Paragraph 3D, Option 1)
   - 25 ppb mica (F)
   - 25 ppb Quikseal (M)
2. Spot larger LCM pill with higher viscosity and higher concentrations (Volume 2, Section 2, Paragraph 3D, Option 1)
3. Proceed to 'Severe losses'

SEVERE LOSSES (50 - 500 bbls/hour)

1. Spot minimum 100 bbl LCM pill containing:- (Volume 2, Section 2, Paragraph 3D, Option 1)
   - Calcium Carbonate (F) 10 ppb
   - Calcium carbonate (M) 20 ppb
   - Quikseal (F) 10 ppb
   - Quikseal (M) 20 ppb
   - Mica (M) 20 ppb
2. Diesel Oil - Bentonite/Guar Gum [50 bbl] (Volume 2, Section 2, Paragraph 3D, Option 6)
3. Sodium silicate/cement treatment [20 bbl/50 bbl] (Volume 2, Section 2, Paragraph 3D, Option 2)

TOTAL LOSSES (> 500 bbls/hour)

1. Diesel Oil - Bentonite/Guar Gum [50 bbl] (Volume 2, Section 2, Paragraph 3D, Option 6)
2. Sodium silicate/cement treatment [20 bbl/50 bbl] (Volume 2, Section 2, Paragraph 3D, Option 2)

3.D. OPTIONS AND PROCEDURES

General Principles

1. Keep the hole full. Have one pump lined up to the drillpipe and one to the annulus. Use seawater if necessary.
2. Close the well in if the level in the riser falls out of sight.
3. Record volumes of each different density fluid pumped to the well to enable estimates of pressures in the well.
4. Always have at least one lost circulation treatment prepared.
5. If possible, spot treatments through OEDP rather than a bit.
Option 1

Conventional LCM Formulations

It is important to match the type of LCM to the type of loss, but the most successful approach is generally to use a cocktail of LCM types and grades. A dual pill (coarse and medium followed by fine) should be considered.

For severe and total losses, the LCM pills should be at least 80 ppb. A 100 bbl treatment should be tried initially. Great care must be taken to avoid plugging the drillstring when using this concentration of LCM. Keep the pits well agitated. A displacement rate of around 400 gpm should be used, and never stop pumping until the LCM is displaced to the well.

The LCM particles should be less than a third of the nozzle size.

Formulations for seepage and partial losses are given in Volume 2, Section 2, Paragraph 3.C.

For severe and total losses, the following recipe will be used initially:-

- Calcium Carbonate (F) 10 ppb
- Calcium carbonate (M) 20 ppb
- Quikseal (F) 10 ppb
- Quikseal (M) 10 ppb
- Mica (M) 20 ppb
- Mica (M) 20 ppb

Increasing the viscosity of the pills may be more beneficial than increasing the LCM concentration in some circumstances.

Preparation

1. When drilling approaches the carbonate section, a dedicated pit should be kept aside for LCM slugs. At least 100 bbls of usable volume should be built. LCM material should be mixed to the maximum concentration that can be kept safely agitated, and made up to 80 ppb at the time of the incident. It is essential to keep this fully agitated. Do not use any of the mud shearing devices for mixing this pill.

'Big Bags' of LCM can be made available to aid the rapid mixing of pills.
2. Ensure that all the restrictions in the BHA and at surface have been reduced to a minimum.

Procedures

1. On encountering severe losses, line up to pump mud down the annulus, and LCM down the drillpipe, monitoring the well at all times.
2. Close the annular preventer if the level in the riser falls out of sight.
3. Pump and displace 100 bbls of 80 ppb LCM. Pump out of the hole while displacing the LCM. Keep the pipe moving to prevent sticking as cavings descend in the annulus. Have a watcher monitoring the pits when pumping and displacing LCM - do not rely on pump strokes alone.
4. Pull back to safety. This will preferably be to the casing shoe, or at least a depth where the bit will be above the top of the LCM pill if all the LCM stayed in the hole (i.e. have a minimum of 100 bbls of open hole beneath the bit).
5. Monitor the displacement pressure at all times. Attempt to keep the annulus full. Use seawater to do this if necessary. Displace all LCM from the drillstring. Displace to leave the hole full of LCM across the loss zone.
6. Circulate across the wellhead for at least two hours. If the LCM has begun to work, close the annular preventer and apply a light squeeze pressure to force the LCM into the fractures.
7. If the treatment does not work, proceed with another LCM pill or alternative treatment. Begin preparing for this as soon as space becomes available.

Option 2

Sodium silicate and cement treatments

In severe mud loss situations where previous treatments have failed to control losses, a combination of sodium silicate and cement will be used. Sodium silicate is pumped ahead of the cement with a fresh water spacer in between. When the cement comes in contact with the sodium silicate in the loss zone it flash sets resulting in either partially or fully sealing off the loss zone.

On 118-CVX-1X the application of sodium silicate without cement allowed up to 65 psi pressure to be applied to the well. This was not enough to offer any great advantage, so the use of sodium silicate without cement back-up was discontinued.

Calcium Chloride Pre-Flush

In formations where the rock is not water wet, the effectiveness of the sodium silicate treatment may be limited. A pill of calcium chloride (at about one third the volume of the sodium silicate) can be pumped ahead to wet the rock with calcium ions. If this is done, pump the calcium chloride with the rig pumps, and the sodium silicate and cement with the cement unit. Initially at least there are no plans to carry out this pre-flush.

Treatment Mechanism
The sodium silicate forms a crystalline precipitate comprising calcium silicate and sodium chloride on contact with connate water, or a calcium chloride pill pumped ahead. This precipitate remains in situ, and stops the cement flowing away before it sets. In addition, when the following cement contacts the sodium silicate, the reaction with the unused sodium silicate flash sets the cement. The operational procedures for pumping this treatment are critical as it is essential that the cement and sodium silicate are kept separate until they hit the formation. A freshwater spacer is used. Placement is designed to leave cement in the well bore across the loss zone to counter-act the tendency of the cement to leak away. It also leaves something to squeeze away if a bridge is formed. Keep pipe well clear of the cement (always pull back to the shoe after carrying out a sodium silicate/cement treatment) and be cautious about disturbing the treatment.

**Preparation**

1. Ensure that all tanks and lines are clean by flushing with drillwater. Use a dedicated tank to hold the sodium silicate. The cement and sodium silicate must never come in contact while pumping. Sodium silicate must also be kept clear of saltwater and CaCl2 solution as it results in the instant formation of a viscous precipitate.

   **NB:** A demonstration of the effects of sodium silicate mixing with cement should illustrate the need for segregation and cleanliness when using this material.

2. Prepare sodium silicate in the dedicated cement batch tank. Mix 80 bbls, plus dead volume of 50:50 by volume of sodium silicate and fresh water solution. This applies to all the types of liquid sodium silicate.
3. Prepare mix water and additives for standard 50 bbls 'G Neat' slurry at 1.90 SG.
4. Final slurry composition will be advised by telex after lab testing.
5. Ensure that the BHA has been checked for restrictions. There should be no nozzles in the bit or floats in the string.
6. Double check all depth and volume calculations.

**Procedure**

1. Pull back to the casing shoe while filling the hole down the annulus with fresh mud (or seawater if necessary) as fast as possible.
2. Space out drill string and close annular.
3. Pump down the annulus to fill the riser. At the same time pump down the kill line to maintain well bore hydrostatic, and to prevent U-tubing back up around the drillstring when the treatment exits the bit.
4. Rig up circulating head and pressure test line to 1000 psi.
5. Pump the sodium silicate/cement plug as follows:

| 40 bbls | Fresh Water pre flush |
| 20 bbls   | Sodium silicate               |
| 10 bbls   | Fresh Water Spacer            |
| 50 bbls   | G-Neat at 1.90 SG             |
| 10 bbls   | Fresh Water Spacer            |
| ** bbls   | Mud displacement              |

6. Have a watcher on the batch tanks checking the volume of the sodium silicate pumped. Do not rely on cement pump strokes.

7. Displace the treatment. Monitor pressures and be prepared to slow down the injection rate as the treatment hits the loss zone. Continue pumping the treatment out of the drillpipe and into the open hole even if further losses are induced. Ideally, all the treatment should be displaced from the drillpipe before it hits the loss zone.

As the sodium silicate and cement starts to exit the drillpipe, reduce the pump rate down the kill line to prevent cement contamination.

Do not at any stage of the operation attempt to reverse circulate if the job cannot be completed as the cement is likely to set while inside the drill string.

8. Stop pumping down kill line and flow-check the well. Open the BOP and move pipe. Wait on cement and monitor well. Keep hole full with mud or seawater. Monitor the volumes of each fluid pumped to the well.

9. Repeat the procedure as required until losses are cured. Use progressively bigger treatments if necessary, but a greater number of smaller treatments may be more effective. Consider reducing the spacer volume between the sodium silicate and cement to 5 bbls on subsequent treatments once the crews have confidence in the placement.

10. Once surface cement samples are set, R.I.H., drill out cement and drill ahead monitoring losses.

**Option 3**

**Visplex LCM pill**

Visplex is a highly thixotropic drilling fluid which gels rapidly as the pressure on it reduces. The mechanism perceived in a lost circulation zone is that it gels up and becomes resistant to flow at some distance from the wellbore. This, together with it's excellent carrying capacity make it a good medium for an LCM pill. Consideration may be given to running Visplex as a drilling fluid if it is successful in this application.

**Preparation**
1. Prepare 30 ppb prehydrated bentonite slurry in a reserve pit. Dilute back to 10 ppb with seawater.
2. Add 1 ppb pre-hydrated Visplex through the caustic barrel. Dry Visplex can be added, but pre-hydrating increases the gel strength.
3. Adjust pH to 10 with caustic soda (approx. 0.5 ppb).
4. Add LCM to Visplex mud. Suggested initial treatment:-

<table>
<thead>
<tr>
<th></th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Carbonate (M)</td>
<td>35 ppb</td>
</tr>
<tr>
<td>Calcium carbonate (C)</td>
<td>15 ppb</td>
</tr>
<tr>
<td>Mica (M)</td>
<td>20 ppb</td>
</tr>
<tr>
<td>Mica (C)</td>
<td>10 ppb</td>
</tr>
</tbody>
</table>

5. This LCM pill may be weighted if necessary. Up to 150 ppb calcium carbonate can be added and pumped through 3 x 16 nozzles.

Procedure

1. Visplex is contaminated by anionic materials such as CMC and PAC. If such chemicals are present in the mud system it will be necessary to pump a seawater or basic gel fluid pre- and post- flush spacer.
2. Displace as with conventional LCM.

Option 4

Flocculated Mud

Flocculating the active mud to increase thixotropy and resistance to flow may be beneficial in certain circumstances. The application to massive losses is doubtful, but this technique may have benefits in slowing losses while other courses are pursued.

Preparation

1. If the mud contains over 15 ppb clay content, flocculate with 4 ppb sodium bicarbonate.
2. If the active contains less than 15 ppb clay content, flocculate with 2 ppb XC or XCD polymer.

Procedure

Displace as with conventional LCM.

Option 5
Diesel - Bentonite plug (DOB)

Preparation

1. Prepare cement unit and chemical batch tanks for mixing of diesel pill. Ensure all valves in contact with mixing lines do not leak. Drain all lines and dry.
2. Prepare diesel oil - bentonite (DOB) in the batch tank as follows:-
3. For a 50 bbl treatment
   o 37 bbl diesel
   o 14,000 lbs bentonite
4. Fill second batch tank with 30 bbls diesel.

Procedure

1. Line up second batch tank and pump 10 bbl diesel down drillpipe.
2. Pump 50 bbls DOB slurry to drillpipe.
3. Pump a further 10 bbls diesel.
4. Displace to loss zone with rig pumps monitoring strokes and pressure.
5. Close BOP before DOB leaves bit.
6. Keep pumping until plug is displaced. Displace to the formation at ~ 6 bbl/min., 3 bbl/min. down drillpipe and 3 bbl/min. down annulus so that a ratio of 1:1 annular fluid:DOB is achieved.
7. After half the treatment is displaced, slow displacement rate to ~ 3 bbl/min., 2 bbl/min. down drillpipe and 1 bbl/min. down annulus
8. Keep the annulus full at all times. It may be necessary to increase the displacement rate.
9. Pull clear of treatment if necessary. When bit is at shoe open well and keep annulus full. If successful, and losses are cured or partially cured, apply a squeeze. This treatment improves with time, a four hour waiting and squeezing period is suggested.

Option 6

Diesel - Bentonite/Guar Gum plug (DOB)

Preparation

1. Prepare as for Option 5, but mix the following in the batch tank:-
2.

   For a 50 bbl treatment  40 bbl diesel
   9250 lbs bentonite
   1500 lbs guar gum

Procedure
Placement should be as for Option 5

Option 7

Diesel - Bentonite/Cement plug (DOBC)

Preparation

1. Prepare cement unit and chemical batch tanks for mixing of diesel pill. Ensure all valves in contact with mixing lines do not leak. Drain all lines and dry.
2. Prepare DOBC gunk in the batch tank as follows:-
   - **Either** 1:1 gel/cement ratio
     - For a 50 bbl treatment
       - 36 bbls diesel
       - 7700 lbs bentonite
       - 7700 lbs class G cement
   - **or** a 1:2 gel/cement ratio
     - For a 50 bbl treatment
       - 40 bbl diesel
       - 3800 lbs bentonite
       - 7200 lbs class G cement
3. Fill second tank with 30 bbl diesel.

Procedure

Initially pump drillstring full of water. Then proceed as Option 5.

Option 8

Barite plug

Preparation

1. Clean out slug tank with drillwater. Flush associated lines and all lines to cement unit with drillwater.
2. Add 30 bbls drillwater to slug tank. Add 0.25 ppb caustic soda and either 0.5 ppb CFCL or 0.75 ppb SAPP. Mix thoroughly.

Procedure
1. Use the following formulation to obtain the desired weight of 2.6 SG.

   Barite : 755 ppb

   Drillwater : 0.49 x desired volume

   i.e. for a 40 bbl treatment need 19.6 bbls drillwater.

2. Assuming 40 bbl of 2.6 SG barite plug required,
3. Transfer 19.6 bbl of the mixwater to the cement unit. Mix 30200 lbs barite as uniformly as possible and pump quickly downhole at the maximum rate. The mix should not be pumped to the drillpipe until it is at the required density, by which time the barite will be visually settling out in the slurry tank.
4. Displace plug with same weight as annular fluid to as near TD as possible and attempt a balanced plug. Underdisplace by two barrels inside drillpipe above the top of the plug in the annulus.
5. Pull well above the plug as quickly as possible. The plug will settle out within 15 minutes after circulation is stopped.
6. In 12.1/4" hole, a 40 bbl treatment will have a height of 84m (liquid) and 42m (solid barite).
7. Circulate and condition mud, through the choke if necessary.
8. RIH and tag top of plug. Prepare to do follow up treatment.

Option 9

Magnaset Cement

Spherelite Cement

Foam cement

Recipes for light-weight cement slurries to follow an initial LCM treatment are still under review. The most common cement type used has been a standard 'G' neat slurry. A reduction in the hydrostatic head by reducing the slurry weight may be advantageous.

As well as a conventional extended slurry, the above cements are also being reviewed.

3.E. REPORTING

The daily drilling report should indicate:-

1. depth of the loss zone, and its height if known.
2. the rate of mud loss (in bbls/hr).
3. the treatment or treatments used (volume, composition etc.).
4. the loss rate after the treatment.
A Lost Circulation Treatment Log has been compiled on Excel, and is available on both rigs. It is essential that these are filled in and sent to HCMC so that the effectiveness of treatments can be readily evaluated.

3.F. ESSENTIAL PLANNING REQUIREMENTS

Casing Design

Design the well so that there is the absolute minimum of open hole between the casing shoe and the loss zone (assumed to be carbonates). This will minimise the risk associated with exposing the young reactive shales overlying the carbonates to large volumes of uninhibited fluid.

The wells must also be designed with the casing set as close as possible to the carbonates to allow successful bullheading. As part of the well planning process, minimum bullheading rates for the expected well profile should be determined. Bruce Swanson at Sunbury can assist with these calculations. The rig pumping capacity must be considered.

A contingency casing string should be available to be set across or through the hydrocarbon bearing and/or loss zone.

Casing will be designed to withstand gas to surface from the top of the carbonate based on highest anticipated pore pressure.

The well will be designed to drill through the loss zone in the optimum hole size. Too small and there is an increased chance of plugging up equipment. Too large and loss volumes will be more difficult to manage and bullheading efficiency is reduced. 12.1/4" or 8.1/2" are preferred.

Equipment Rental

Dedicated 100 bbl batch cement tanks should be available for sodium silicate, gunk and other treatments. Dedicated pipework should be run direct to the cement unit suction. This should preferably have a gravity feed, and the pipework should be as straight as possible. Consider building a frame or rigging up a bulk hose to aid filling the batch tanks.

Have a spinner survey or temperature survey available ready to pinpoint the loss zone if necessary.

Chemical Procurement

Ensure enough chemicals are on board to build large volumes of mud, and for multiple lost circulation treatments. Big bags of barite have been sourced. Big bags of LCM remain an option.
Determination of the top carbonate

An intermediate VSP may be programmed on all wells to refine the top errorbar of the carbonate. Casing will be set 10m above this error bar. ROP will be controlled on approaching the carbonate.

An RFT should be programmed for the top carbonate to quantify formation pressure. Electric logs can be safely run with a shooting nipple and a wireline BOP with losses up to 30 bbls/hr. A sump of at least 10m is preferred for the RFT.
2.4 STATIC UNDER BALANCED DRILLING PROCEDURES

GENERAL

This method will be considered for use in Vietnam drilling operations when the following criteria apply:-

1. Severe losses have been encountered while drilling in a known carbonate section of a well which cannot be cured by conventional means.
2. The hydrocarbon leg has been cased off and the water leg of the carbonate reservoir is to be drilled out to a seal at the base of the carbonates.
3. Accurate acquifer pressure is known. If not known it must be ascertained by RFT before commencing this operational practice.
4. Specific approval of the Drilling Manager has been obtained at both the planning and implementation stage.
5. The rigsite procedures to be adopted must be drawn up by the BP Rep and be submitted to the Drilling Manager for approval before use.

PRINCIPLE

Based on results from RFT data, it is known that carbonates can switch from a losing to a flowing situation with a very small change in hydrostatic head—as little as 15 pi.

As such a carbonate section can be drilled with a mud weight that gives a static overbalance of zero but when circulating the ECD exerts sufficient overbalance to create severe losses.

The procedure for static under balanced drilling is based on the reducing the dynamic hydrostatic pressure exerted by the mud column when circulating to a level which minimises losses to an acceptable level. This will usually result in the static hydrostatic head being lower than formation pressure i.e. if the ECD is lost the well will flow.

As such when the pumps are to be turned off for a connection a procedure must be in place to displace heavy mud down the annulus and drillpipe to ensue that the hydrostatic head with the pumps off equals that generated by circulating (ECD) and that the well remains in a safe state (controllable losses). Similar procedures must be in place for logging and tripping.

In addition specialised techniques for well control must be developed and understood.

PROCEDURES

Prepare procedures for Static Underbalanced Drilling. These should include:-
1. Roles and responsibilities for rig personnel.
2. Mud management.
3. Surface set up.
4. Logistics.
5. Well control.
6. How connections will be carried out.
7. How the well will be logged.
8. Tripping Procedures.
9. Contingency planning.
   - What to do if losses down annulus decrease;
   - What to do if losses down annulus increase;
   - What to do if annulus level rises/well flows;

The rig specific procedures will be submitted to the Drilling Manager for discussion and approval. Attention is drawn to procedures used on the LT-Obs-1 well and the lessons learned.

After approval of procedures it will be the Drilling reps. responsibility to ensure that all relevant members of the Drilling Rig Crew and Service Company Personnel are fully briefed and understand the procedure to be adopted.

These personnel will include the following:-

1.

Drilling Contractor: Toolpusher
   Tourpusher
   Both Drillers
   Both Assistant Drillers
   Both Derrickmen

3.

Service Companies: Cementing Engineer
   Mud Engineers
   Mud Loggers
   Wireline Engineers
2.5 FLOATING MUD CAP DRILLING TECHNIQUES

This method will be considered for use in Vietnam drilling operations when the following criteria apply:-

1. Severe losses have been encountered while drilling the carbonate section of a well which cannot be cured by conventional means.
2. The hydrocarbon leg has been cased off.
3. The pore pressure at the loss zone has been ascertained.
4. The estimated material requirements for the process can be supported by the logistics available.
5. A clear statement of section TD is available.
6. There is a clear understanding of the fact that no cuttings samples will be taken, additional logging to determine geological depth may be required and the high cost of this operation with respect to mud consumables and increased rig time.

The actual use of the Mud Cap Drilling Technique will be authorised by the Drilling Manager.

PRINCIPLE

Drill blind with seawater down the drill string.

Annulus kept full with mud of density slightly more than pore pressure with agreed safety margin.
With pumps turned off monitor losses down annulus.
Examine logistics as to whether mud volume can be maintained over time required to drill section.
Prepare procedures for mud cap drilling. These should include:-

1. Roles and responsibilities for rig personnel.
2. Mud management.
3. Surface set up.
4. Logistics.
5. Contingency planning
   - What to do if losses down annulus decrease;
   - What to do if losses down annulus increase;
   - What to do if annulus level rises/well flows;
   - Well control.

The rig specific procedures will be submitted to the Drilling Manager for discussion and approval.

Attention is drawn to the procedures used on 06.LD-1X.
2.6 ABANDONMENT / SUSPENSION PROCEDURES

6. A. GENERAL

Before the suspension or abandonment of an exploration well, permission must be obtained from Petrovietnam. A programme should be sent to Petrovietnam for approval before the suspension or abandonment operations begin. If practicable, 5 days notice should be given.

All necessary contact with Petrovietnam will be made by the SDE/DS in BP HCMC.

6.B. WELL SUSPENSION CRITERIA

An exploration well may be suspended for one of the following reasons:-

- The well has not been completed, but the rig has to move off location for some reason.
- The well has been successfully drilled but has not been fully tested.
- The well has been drilled and tested and may possibly required in the future as part of a field development.

6.C. ABANDONMENT & SUSPENSION REQUIREMENTS

Suspension

The main requirements of the well suspension programme are:-

1. To leave the well in a safe condition downhole such that, if the wellhead is accidently damaged or removed, the well will retain pressure integrity and there is no possibility of the well flowing.
2. To allow the well to be re-entered at a subsequent date and a BOP installed without recourse to repair work. To cover this requirement a corrosion cap will be run to protect the wellhead and its sealing areas.
3. To leave a well in a condition such that subsequent abandonment can be carried out by a Diving Support Vessel which will be able to recover the wellhead without rig intervention.
4. To ensure that any seafloor obstruction is minimised.

Abandonment

The main requirements for the well abandonment programme are:-

1. To leave the well in a safe downhole condition such that the well will retain pressure integrity and there is no possibility of the well flowing when the BOP or wellhead is removed.
2. To leave the seabed around the wellhead clear of drilling related debris.
6.D. WELL PLANNING REQUIREMENTS

To cover the requirements stated above it is usual to plan wells with the following features:-

1. Casing cementation is programmed so as to cement all potentially productive formations.
2. Formations having different pressure regimes are isolated from each other.
3. The cement used for any cement plugs is designed to have a minimum compressive strength of 3000 kPa (435 psi) after it has hardened for at least eight hours.
4. Silica blend cement is used where temperature effects may cause long term degradation of neat class G cement.
5. The suspended well is filled with fluid of sufficient density to overbalance the formation pressure found in the well and should be treated to minimise corrosion of the casing and tubing.

6.E. PLUG BACK REQUIREMENTS

General

Refer to Table 1 for a summary of the minimum plug requirements.

The following requirements apply to both abandonments and suspensions:-

1. If the well has been tested then the different test intervals will normally be separated from each other by bridge plugs, or by both bridge plugs and cement plugs if space allows. A cement plug will be placed across the shallowest test interval with a minimum acceptable height above the interval of 30m. This plug will be tagged and pressure tested to a value of 500 psi above the formation leak-off pressure of the tested interval.
2. Where there is an open hole section a cement plug will be placed across the casing shoe from 50m above to 50m below the shoe. This plug will be tagged and pressure tested to 500 psi above the formation leak-off pressure at the casing shoe. Hydrocarbon bearing formations or formations of differing pressure regimes in the open hole will be isolated by cement plugs extending 30m above and below such formations. Where the open hole section is relatively short (less than 250m) and small diameter (8 1/2” or less) it is common practice to fill the entire section, from TD to 50m inside the casing shoe, with cement. Where the open hole section is long and does not contain hydrocarbon bearing formations, nor differing pressure regimes, then a cement plug across the casing shoe will be sufficient.

Where possible, in the case of an unsuccessful fishing operation for stuck pipe, the fish shall be perforated and cement shall be pumped through the perforations to isolate any open sands that are present.
If the condition of the open hole precludes running pipe into it, then a bridge plug will be set 30m above the shoe with 50m of cement above the bridge plug.

3. Where a production liner has been run a cement plug will be placed across the liner overlap, from 50m above to 50m below the liner top. This plug will be tagged and pressure tested to 500 psi over the formation leak-off pressure at the casing shoe behind the liner.
4. There should be at least one bridge plug between the open hole and surface. The bridge plug will normally be placed at c. 200 m below seabed, i.e. just underneath the surface cement plug. The bridge plug should be pressure tested to the same surface pressure as the next deepest plug. A note of the volume pumped to achieve the test pressure should be made and compared with the previous test's volume. A reduction in volume to achieve the test pressure will be deemed to be a good test of the bridge plug.

5. A 100m surface cement plug will be set 200-100m below the seabed, normally on top of a bridge plug. The purpose of this cement plug is to act as a debris barrier and it will not be tagged or pressure tested.

**Suspension only**

In addition to the common requirements listed above, the following requirements apply solely to well suspensions:

1. A corrosion cap will be run and the wellhead filled with hydraulic oil.
2. The guide wires should be cut by the ROV and an attempt made to clear the post tops of wireline debris.
3. A suspension status diagram will be completed by the Ops DE (with input from offshore) and approved by the Senior Drilling Engineer. This must show all information concerning casing strings and wellhead equipment and accurate depths of suspension plugs, etc. In particular, the wellhead and connector types and type of corrosion cap installed must be detailed.

**Abandonment only**

In addition to the common requirements listed above, the following requirements apply solely to well abandonments:

The choice of method of wellhead severance is outlined in section "Wellhead Severance".

1. All casing strings will be cut off a minimum of 3m below the seabed. Sometimes it will be necessary to recover a long section of uncemented casing for future re-use in this instance a bridge plug will be set 50m below the cut depth and a 100m cement plug will be set over the casing stub i.e. from 50m below to 50m above
the cut. The cement plug will be pressure tested to 500 psi over the formation leak-off pressure at the next deepest casing shoe.

2. There shall be no un-isolated route behind a string of casing from an openhole section to surface. If the casing/casing overlap has not been isolated with cement then the casing string will be cut deep and isolated in the same manner as in step 1 of "Abandonment Only" above. If the annular top of cement has not been identified on a log, then the top of cement will be assumed by calculation.

If there is the possibility of a pressure build-up in the annulus behind a casing string, then it will be necessary to perforate the casing below the wellhead while maintaining full BOP control prior to starting casing cutting operations. All investigative work behind uncemented casing must be done with the BOP stack on the wellhead.

3. When cutting casing the shoe strength at the previous casing shoe must be high enough to withstand the mud weight in the hole. If it is not, then the mud weight will have to be reduced.

4. An attempt should always be made to recover the TGB, if one was installed. In some cases this may be impossible due to the TGB being buried below the mudline and in this case it is sufficient to cut the guide wires at the seabed.

5. After retrieving the PGB, an ROV survey (or equivalent) must be carried out to confirm that the seabed is clear of drilling related debris within a 70m radius of the wellhead (but see step 4 of "Abandonment Only" above). If debris is present then BP is obliged to recover it, and the recovery operation should be agreed with the Drilling Superintendent. A Seabed Clearance Certificate must be issued by the ROV (or Diving) Supervisor stating that the seabed is clear (or alternatively that there is debris that has not been recovered). This should be signed by the Diving (ROV) Superintendent and countersigned by the BP Drilling Supervisor who should ensure that this certificate is sent to the rig's DE Ops.

6. An abandonment status diagram will be completed by the Ops DE (with input from offshore) and approved by the Drilling Manager. This must show all information concerning casing strings and accurate depths of abandonment plugs etc.

6.F. PLUG BACK GUIDELINES

1. Prior to commencing the plug-back, ensure that the well is circulated clean of produced fluids.
2. Cement plugs will generally be set using a 180m long tubing stinger with a diverter sub on the bottom. The length of any one cement plug shall not exceed 150m. Longer sections will be cemented with plugs set in series on top of one another.
3. Cement plugs will generally be set above a 100m viscous pill to prevent the cement from slipping downhole. This will not apply where the plugs are set on bottom or directly above another cement plug or bridge plug.
4. All cement plugs will be balanced plugs, under-displaced by 2-3 bbls.
5. When tagging plugs minimum bit weight of 10,000 lbs and a slow pump rate will be used to ensure that the plug will not wash away. If the plug is soft, it may be necessary to WOC before tagging again.
6. Before running a bridge plug a wireline gauge ring should be run.
7. After setting the final cement plug the riser will be displaced to sea water at the wellhead before pulling the BOP/riser.

6.G. WELLHEAD SEVERANCE

There are two basic methods available to cut casing, i.e. mechanical or explosive cutting.

The choice of method will largely depend on water depth and experience. The following points should be considered:-

a. If water depth is less than +/- 100m, then the rig may have to move off station if explosive cutting is used.

b. In deep water (say greater than 300m), mechanical cutting is probably best avoided due to the need to rotate a long unsupported drill string. (The intermediate and production strings can of course be mechanically cut before pulling the riser).

c. At intermediate depths either method is applicable although modern mechanical cutting methods have a high probability of success and will usually be the preferred option. If the first attempt to cut the 20/30" casing fails, provided all indications show that the mechanical cutters have been fully extended, then further attempts should be made to cut the casing explosively.

<table>
<thead>
<tr>
<th>Plug Setting Points</th>
<th>Top of Cement</th>
<th>Bottom of Cement</th>
<th>Alternative Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All porous/permeable zones, zones with differing pressure regimes. Loss circulation and hydrocarbon zones.</td>
<td>Min. 30m above</td>
<td>30m below</td>
<td>For long open-hole sections not containing hydrocarbons and in the same pressure regime this is not required. If hydrocarbon bearing zones have been tested, the zones should be separated by a bridge plug.</td>
</tr>
<tr>
<td>2. Casing shoe (open hole below).</td>
<td>50m above</td>
<td>50m below</td>
<td>If the condition of the open hole precludes running pipe into it, set a bridge plug 30m above shoe with 50m cement above bridge plug.</td>
</tr>
<tr>
<td>3. Top of production liner.</td>
<td>50m above</td>
<td>50m below</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 1 - CEMENT PLUG/BRIDGE PLUG REQUIREMENTS FOR THE ABANDONMENT AND SUSPENSION OF WELLS
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. Perforations.</strong></td>
<td>Min. 30m above</td>
<td>30m below</td>
<td>For a suspended well, in exceptional circumstances, where formations have been fractured/stimulated then cement across the perforations may be replaced by a bridge plug above with 50m of cement above the bridge plug.</td>
</tr>
<tr>
<td><strong>5. Annular spaces (there should be no communication between seabed and open hole).</strong></td>
<td></td>
<td></td>
<td>Cut casing and revert to item 7.</td>
</tr>
<tr>
<td><strong>6. Top of cut casings.</strong></td>
<td>50m above</td>
<td>50m below</td>
<td></td>
</tr>
<tr>
<td><strong>7. Surface plug (100m plug).</strong></td>
<td>100m below seabed</td>
<td>200m below seabed</td>
<td>If the casing is cut shallow and plugged as in item 7, the requirement for a surface plug will have been satisfied.</td>
</tr>
<tr>
<td><strong>8. Bridge plug.</strong></td>
<td></td>
<td></td>
<td>There should be at least one bridge plug between the open hole and surface. Normally, set below the surface cement plug. Alternatively set 50m below the depth of cut of the production/intermediate casing shoe.</td>
</tr>
</tbody>
</table>
2.7 DRILLING IN PRESSURE RAMPS

See the Drilling Completion Reports for KCT-1X, HT-1X, and HT-2X for problems encountered with severe pressure ramps. Reference also to the Well Design Document.'

This procedure is to be used for drilling in formations which exhibit pore pressure increase with depth of greater than 3 psi/metre.

7.A. DISCUSSION

When drilling exploration wells in Vietnam, formations which exhibit pore pressure increases with depth of greater than 3 psi/metre with levels seen to be approaching the 15psi/metre figure.

These formations will normally be in a clastic sequence consisting mainly of mudstone with interbedded sandstones and carbonates. The possibility of encountering these formations will be highlighted in the well programme.

The prediction techniques listed (and any other which may be available) will be used to estimate pore pressures at bit depth and ahead of the bit to ensure that mud hydrostatic is maintained above pore pressure.

Drilling operations will be modified to assist in these pore pressure prediction methods.

The BP Rep will be responsible for raising the mud weight in line with these pore pressure estimations consulting with the DS and DM as necessary and logging the reasons in the mud weight log.

The Operational procedures attached will be used when required. This requirement will be highlighted in the well specific procedures or directly by the DS/DM.

Confirmation of estimated pore pressures can be attempted at any time using the RFT tool with the associated costs and risks. The decision to run an RFT for Drilling purposes will be made by the DS/DM in consultation with the BP Rep, Operations Geologist and Operations PE.

7.B. PORE PRESSURE PREDICTION TECHNIQUES

The rig site team consisting of the BP Rep, Wellsite Geologist, Mud Loggers and Pore Pressure specialist (if available) backed up by the Operations team in HCMC will determine the best estimate of the pore pressure using the optimum pore pressure prediction techniques for the well being drilled. This may be one or a combination of any of these techniques:-

Drilling Exponent
The wellsite geologist in conjunction with the Mud Logging crew and Pore Pressure expert (if available) will calculate the Drilling Exponent and estimate the pore pressure based upon this. Rotary drilling with tricone bits is the preferred method to optimise Drilling Exponent measurements. Drilling parameters are to be maintained as constant as possible to allow the most accurate assessment to be made.

**Mud Gas Level**

For definition purposes the level of gas in the mud is due to one or a combination the following:

- **Background Gas**
  
  The general level of gas carried by the mud purely as a function of circulating in open hole.

- **Drilling Gas**
  
  Gas which has entered the mud due to the actual drilling of the formation, i.e. the gas contained in the matrix of the rocks which have been drilled.

- **Connection Gas**
  
  The gas which enters the mud when a connection is made due to reduction in hydrostatic due to loss of ECD and due to swabbing while pulling back.

- **Swabbed Gas**
  
  The gas which enters the well due to swabbing. This may be caused by tripping or by simulating tripping.

- **Trip Gas**
  
  The gas which enters the mud during a trip which is measured after a trip has taken place.

- **Pump Off Gas**
  
  The gas which enters the mud due to turning off the mud pumps and removing ECD from the hydrostatic pressure on the bottom of the well.

It is imperative for pore pressure estimation that the gas levels in a drilling mud are correctly interpreted and the above definitions adhered to.

Gas levels are normally recorded on the Gas Logger. The FID system is also available for further analysis.
Pore pressure can only be definitively assessed on the basis of observations of trip gas, connection gas, swab gas and pump off gas. If any of these are observed then pore pressure levels are close to mud hydrostatic.

Increasing background gas levels can indicate increasing pore pressure if correctly determined and analysed - it is important that drilled gas level content of background gas is understood.

Pore pressure evaluation by analysis of gas levels will be carried out by the BP Rep and the Wellsite Geologist in conjunction with the Mud loggers and Pore Pressure specialist.

**Drilling Parameters**

Increased drilling torque, drag on connections and cuttings size may all be used to indicate that pore pressure may be increasing.

**LWD (Log While Drilling)**

Predictive models based on LWD data are available. The Wellsite Geologist will advise on any predictions used involving LWD data.

**Predictive Models**

These will be available to the Wellsite geologist who will advise the BP Rep on the formation pressure predicted by these models.

**7.C. DRILLING OPERATIONS PROCEDURES**

Drill ahead constantly monitoring all gas levels, Drilling Exponent and any other available data.

**Pore Pressure/Depth gradient**

1. Raise mud weight according to pore pressure estimations maintaining an agreed overbalance. (This will be determined by discussions between the BP Rep and the DS). All mud weight increases and decreases will be logged.
2. If a gradient for the rate of pore pressure increase can be determined then raise mud weight using the gradient as a guideline but always using the gas levels as definitive during drilling.
3. Pore pressure estimates can be checked by carrying out pump-off and/or swab tests as required and monitoring connection and trip gas.
4. Circulate bottoms up at any time to determine correct background gas levels or in order to assess pump off gas/swab gas/connection gas levels.
5. If background gas levels above 2% are encountered, bottoms up must be circulated to ensure that the level drops off after bottoms up. If levels do not drop consideration should be given to raising the mud weight or performing pump off/swab checks.
6. Mud weight will be raised at least according to the estimated pore pressure gradient if drilling mudstone only and will only be adjusted once a permeable/porous formation has been drilled allowing a more accurate assessment by use of pump off/swab gas techniques.

**Pore Pressure/Depth gradient > 5 psi/metre**

All the procedures outlined above will be carried out along with the following:-

1. Simulated connections will be made every single.
2. Bottoms up may be circulated after every simulated connection. This decision will be based on the background gas levels encountered, general well conditions, mud weight in use and estimated gradient. The decision will be made by the BP Rep in consultation with the DS and DM.

The situation whereby the annulus is overloaded with information will be avoided.
2.8 FOR DRILLING IN KICK TOLERANCE CALCULATIONS

The following kick tolerance calculations shall be carried out and reported on the 24 hrs drilling report on a daily basis.

<table>
<thead>
<tr>
<th>CALCULATION NUMBER</th>
<th>DEPTH TO BE USED (M)</th>
<th>MW TO BE USED (SG)</th>
<th>PORE PRESSURE TO BE USED (SG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Present depth</td>
<td>MW in hole now</td>
<td>MW in hole now</td>
</tr>
<tr>
<td>2</td>
<td>Present depth +50meters</td>
<td>MW in hole now</td>
<td>MW in hole now</td>
</tr>
<tr>
<td>3</td>
<td>Present depth +50meters</td>
<td>MW in hole now +0.05 SG</td>
<td>MW in hole now +0.05 SG</td>
</tr>
<tr>
<td>4</td>
<td>Present depth</td>
<td>MW in hole now</td>
<td>MW in hole now +0.05 SG</td>
</tr>
<tr>
<td>5</td>
<td>Present depth +50meters</td>
<td>MW in hole now</td>
<td>MW in hole now +0.05 SG</td>
</tr>
</tbody>
</table>

A computer programme approved by the HCMC site team shall be used to carry out these calculations. This is at present available on floppy disc format for PC's and by machine to machine on HP100/200. The BP Rep is to make sure he has the correct version available.

The actual kick tolerance figure used for Drilling Policy determination is calculation number 1.

The calculations are intended to allow a degree of standardisation in the way we deal with kick tolerance and introduce a standard look ahead format.

**Constants:**

\[
\text{Gas gradient} = 0.1 \text{ psi/ft} = 0.32808 \text{ psi/m} = 0.23 \text{ SG}
\]

Safety factor = 100 psi

No temperature effect.

The DM shall be informed when the Kick Tolerance falls below 50 bbl. Kick-Tolerance below 25 bbl requires dispensation from Drilling Policy, approved by the required Technical Authority.
2.9 DRILLING IN REEFAL CARBONATES

PREPARATIONS

1. All personnel should be aware of the warning signs for a kick or losses, such as a drilling break, pit gain / loss, increased flowrate and increase in background gas levels.

2. While the carbonates are 'exposed' well control becomes a priority. Personnel should be fully aware of:-
   - the implications on well control due to lost circulation
   - shut in procedures
   - well kill techniques
   - how they are lined up for losses
   - The implications on well control with mudstones exposed above the carbonates

3. Kick drills, as per BP Well Control Manual, and lost circulation drills should be performed on a regular basis with all crew members (including mud loggers). The BP Representative should be fully satisfied with the drill crews response and actions before drilling into the carbonates. Response time should be reported to the Drilling Superintendent on the daily drilling report.

DRILLING INTO THE CARBONATES

1. A string of casing will be set 10m above the shallowest error bar on the carbonates.

2. The reefal carbonates will not be penetrated unless the well is capable of taking gas to surface. The pore pressure used, if not known, will be the P95 figure.

   Note:

   An additional string of casing may have to be committed before drilling into the carbonates if the amount of reactive or dispersive mudstone exposed gives a high risk of stuck pipe or the open hole section cannot withstand gas to surface.

3. Mud Weight

   The mud salvaged from the previous hole section will be used to drill the this hole section. If additional mud volume is necessary particularly if losses are encountered Gel/CMC mud should be built to maintain mud volumes.

   Mud weight shall be based on the estimated pore pressure at top carbonate and be sufficient to give a static overbalance of 90 psi on prognosed most likely pore pressure. (Note: The 90 psi is experience derived). No riser margin is applied. Having penetrated the carbonates it may be possible to lower the mud weight having revised the pore pressure in line with depth to top carbonate and therefore gas column height and pore pressure.
4. Prepare a pit with 100 bbls (pumpable) LCM as per the Lost Circulation Procedures - option 1.

5. Make up the BHA for drill out and drilling to top carbonate. This BHA should be slick and no Totco ring should be run. The bit used to drill this interval should be run with large nozzles to improve hydraulics while drilling the mudstone yet allow LCM to be pumped in the event losses are encountered at top carbonate.

6. The following BHA requirements must be adhered to:
   - No stabilizers
   - No Totco ring
   - No nozzles in bit

7. After carrying out LOT, confirm formation integrity for gas to surface capability with the DS.

8. While drilling to top carbonate penetration rate should be controlled to around 5 m/hr. It is important that drilling parameters are maintained as constant as possible to enable changes in ROP and torque to be identified.

   **Note:**

   5 m/hr is a guideline. The bit should be allowed to drill at an ROP which allows drilling parameters to be held constant.

9. If any changes in drilling parameters are encountered, drill no more than 1m of drilling break and circulate bottoms up. During this phase, all drilling should be done with the compensator in locked mode (if weather permits), or with the compensator as fully open as possible. This is to minimize penetration of new formation in the event of a drilling break.

10. **Initially, the carbonates should not be penetrated by more than 2m until samples have been circulated and it is established that the well is stable.**

11. If it is planned to take an RFT to confirm the pore pressure in the carbonates, this should be done as soon as sufficient rat hole is available.

12. Drill ahead through the carbonates as per programme.

   **If losses occur follow the guidelines in the BP Vietnam Lost Circulation Manual. Carry out frequent lost circulation drills with all crews.**

13. When tripping, pump out of the hole to eliminate any possibility of swabbing an influx.

14. It is normal practice to set a string of casing once the hydrocarbon / water contact has been penetrated.

15. If losses are encountered in the reefal carbonates without any hydrocarbons being exposed, consideration will be given to using the 'Drilling on Balance' Technique or Mud Cap Drilling Technique. Details are in Vietnam approved Procedures Section.