Petroleum Exploration Reports
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Pacific Oil & Gas Pty. Limited

WELL PROPOSAL - BURDO 1, EP23

McARTHUR PROJECT AREA

Author: S. A. Hibbird
Date: June, 1993
Submitted to: K. D. Tuckwell
Copies to: Northern Territory Department of Mines & Energy - Darwin
          CRAE Central Information Services - Canberra
          Pacific Oil & Gas Pty. Limited - Box Hill

Submitted by: [Signature]
Accepted by: [Signature]

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CRAE Report No. 304857
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APPENDIX 3  Recommended Bit and Hydraulics Programme
APPENDIX 4  CRA Exploration Environmental Policy

LIST OF PLANS

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<thead>
<tr>
<th>TITLE</th>
<th>SCALE</th>
<th>PLAN NO.</th>
</tr>
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<tbody>
<tr>
<td>Burdo 1 Proposed Location</td>
<td>As shown</td>
<td>PetNTcw4975</td>
</tr>
<tr>
<td>Burdo 1 Proposed Well Design</td>
<td>1:10,000</td>
<td>PetNTcw4969</td>
</tr>
<tr>
<td>Burdo 1 Proposed Location Annotated Seismic Section Line 89-203</td>
<td>1:25 000</td>
<td>PetNTcw4973</td>
</tr>
<tr>
<td>Burdo 1 Time Depth Curve (Proposed)</td>
<td>As shown</td>
<td>PetNTcw9380</td>
</tr>
<tr>
<td>EP23 Vegetation Plan</td>
<td>As shown</td>
<td>PetNTcw4978</td>
</tr>
</tbody>
</table>
1 GENERAL INFORMATION

1.1 Objectives

The proposed Burdo 1 well is to be drilled by Pacific Oil & Gas Pty Limited as operator for Exploration Permit 23 in the Northern Territory. The well is located approximately 25km north-west of Tanumbirini Homestead, which is situated midway between Daly Waters and Borroloola on the Carpentaria Highway (Plan PetNTcw4975).

The Burdo 1 well is designed to test a postulated fracture play in the upper Roper Group section at the crest of a large two-way rollover identified by seismic. Important reservoir and source rock information will be obtained to evaluate the prospectivity of EP23. Burdo 1 will provide the only seismic well control in EP23, and the north eastern Beetaloo sub-Basin. The well control will greatly improve the confidence in seismic depth conversion in this region.

1.2 Well Data

<table>
<thead>
<tr>
<th>Well Name:</th>
<th>Burdo 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRAE Drillhole No</td>
<td>RD92MB25</td>
</tr>
<tr>
<td>Permit:</td>
<td>EP23</td>
</tr>
<tr>
<td>Operator:</td>
<td>Pacific Oil &amp; Gas Pty Limited 100%</td>
</tr>
<tr>
<td>Location:</td>
<td>Approximately 25km north-west of Tanumbirini</td>
</tr>
<tr>
<td></td>
<td>Latitude: 16°15'09.2&quot; South</td>
</tr>
<tr>
<td></td>
<td>Longitude: 134°30'33.1&quot; East</td>
</tr>
<tr>
<td></td>
<td>AMG: Zone 53</td>
</tr>
<tr>
<td></td>
<td>447 553.4 East</td>
</tr>
<tr>
<td></td>
<td>8 203 058.5 North</td>
</tr>
<tr>
<td></td>
<td>1:250 000 Sheet: Tanumbirini SE53-2</td>
</tr>
<tr>
<td>Elevation:</td>
<td>Ground level (GL) 267m AHD</td>
</tr>
<tr>
<td></td>
<td>Kelly bushing (KB) 271.9m (Datum)</td>
</tr>
<tr>
<td>Datum:</td>
<td>Unless otherwise stated the kelly bushing (KB) is to be used as a datum for all measurements in the well.</td>
</tr>
<tr>
<td>Duration:</td>
<td>Approximately 28 days</td>
</tr>
<tr>
<td>Prognosed Total Depth:</td>
<td>1500m below KB (Vertical)</td>
</tr>
<tr>
<td>Spud Date:</td>
<td>August 18th, 1993</td>
</tr>
<tr>
<td>Drilling Contractor:</td>
<td>Rockdril Contractors Pty. Ltd.</td>
</tr>
<tr>
<td>Rig No:</td>
<td>Rig 22</td>
</tr>
</tbody>
</table>
### Prognosed Stratigraphy

<table>
<thead>
<tr>
<th>Layer</th>
<th>GL</th>
<th>KB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undifferentiated Tertiary/Cretaceous</td>
<td>Surface</td>
<td>4.9m</td>
</tr>
<tr>
<td>Jinduckin Formation</td>
<td>60m</td>
<td>64.9m</td>
</tr>
<tr>
<td>Tindall Limestone</td>
<td>199m</td>
<td>203.9m</td>
</tr>
<tr>
<td>Antrim Plateau Volcanics</td>
<td>298m</td>
<td>302.9m</td>
</tr>
<tr>
<td>&quot;Hayfield Mudstone&quot;</td>
<td>414m</td>
<td>418.9m</td>
</tr>
<tr>
<td>&quot;Jamison Sandstone&quot;</td>
<td>480m</td>
<td>484.9m</td>
</tr>
<tr>
<td>Kyalla Member</td>
<td>570m</td>
<td>574.9m</td>
</tr>
<tr>
<td>Moroak Sandstone Member</td>
<td>1151m</td>
<td>1155.9m</td>
</tr>
<tr>
<td>Total Depth</td>
<td><strong>1495.1m</strong></td>
<td><strong>1500.0m</strong></td>
</tr>
</tbody>
</table>

### Communications and Reporting

A daily drilling and geological report will be faxed to Pacific Oil & Gas Pty Limited, OZOIL Production Services, and to the Northern Territory Department of Mines and Energy (NTDME) office in Darwin. The operator will notify all parties of any departures from the Well Proposal, any drill stem tests and prior to the abandonment of the well.

Wireline logs, drill stem test results and other critical data will be forwarded to the above parties either by fax or overnight courier. Tour sheets, cuttings and core descriptions, mudlog data and cost reports will be forwarded to Pacific's Box Hill office on a weekly basis.

A Well Completion Report, including all data derived from the well, will be prepared and forwarded to the above parties as soon as possible following the completion of field operations.

### Persons Responsible

Final and statutory responsibility for the Company's exploration programme in the Northern Territory exploration permit EP23 lies with Dr Kevin D. Tuckwell, Chief Geologist. Operational related matters are the responsibility of Iain Clementson, Principal Geologist. All operational and emergency response matters should be directed to:-

Pacific Oil & Gas Pty Limited  
826 Whitehorse Road  
BOX HILL VIC 3128  

Dr. K. D. Tuckwell  
Ph: (03) 895 3082  
Ah: (03) 890 7809  

Mr. I. M. Clementson  
Ph: (03) 895 3036  
Ah: (03) 842 8992

### Emergency Procedures

#### 1.5.1 Emergency Medical Assistance (EMA) Plan

Emergency medical assistance can be attained through the Katherine Hospital. The Hospital can be contacted 24 hours a day on 729 211 or via VJY on HF radio frequencies 2360 or 6840. The air ambulance service provided by Katherine Hospital will land at Tanumbirini Station.
A night evacuation will require the airstrip to be illuminated. Details regarding the night use and other information on the airstrip is included in Appendix 2. The air ambulance has a response time of approximately 1 hour from Katherine.

A road ambulance service will be despatched from Katherine Hospital if the air ambulance is unavailable. This service will take approximately five hours to reach Tanumbirini Station.

Medical assistance can be obtained for minor injuries/complaints at either Borroloola or Mataranka Community Health Centres.
Telephone: Borroloola 75 8757
Mataranka 75 4547

A Pacific Oil & Gas representative, holding a current Level III Occupational First Aid Certificate (Victoria) will be nominated as the site Occupational Health and Safety officer. He or she will be responsible for the management of any injuries on site, will co-ordinate an EMA if necessary and will ensure that first aid equipment is well maintained and serviceable.

For first aid procedures, the authorised manual of St John Ambulance Australia "Australian First Aid Vol. 1" will be referred to. A copy of this manual will be provided with all first aid kits, in the first aid room, on the rig and in the mess.

A copy of the Emergency Medical Assistance Plan incorporating the above information will be beside each telephone and in all first aid kits.

Further first aid information is included in Sections 10 and 11 of Appendix 2.

1.5.2 Bushfires

In the event of a bushfire the procedure below should be followed:

1. Contact the station manager, Greg Campbell on (089) 759929.

2. Contact the Bushfires Council Northern Territory, Regional Headquarters in Katherine on (089) 721629.
   After Hours:
   (i) Gary Eason (089) 723324 or
   (ii) Alan Davis (089) 723200 or
   (iii) Gary Palmer (089) 721416

1.5.3 Police

The Police can be contacted on Mataranka (089) 754511 or Katherine (089) 720111
1.5.4 Fall Back Communications

Fall back communications can be achieved via:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PHONE</th>
<th>HF RADIO</th>
<th>Frequency (KHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royal Flying Doctor Service Alice Springs</td>
<td>(089) 521033</td>
<td>VJD</td>
<td>2020, 4350, 5410, 6950</td>
</tr>
<tr>
<td></td>
<td>(077) 432800</td>
<td>VJI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2020, 5110, 6965</td>
</tr>
<tr>
<td>CRA Exploration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alice Springs</td>
<td>(089) 530229</td>
<td>VJD435</td>
<td>7770</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 8MA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VJD285</td>
<td>10301 (predominantly)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or 8EZ</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VJQ601</td>
<td>7770</td>
</tr>
<tr>
<td></td>
<td>(007) 174033</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24 hours)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. Pre-arranged call-in times are necessary for radio communications with CRAE regional offices.
2. To place a radio phone call during office hours call the RFDS on any of the frequencies listed above.
3. To place an emergency call through to the RFDS after office hours, use frequency 2020 only, and press the red emergency call button on your radio set.

1.6 Contact Numbers and Addresses

Persons and organisations involved in the 1993 drilling programme can be contacted at the following locations:-

Operator:

PACIFIC OIL & GAS PTY LIMITED
Box Hill office
826 Whitehorse Road
Box Hill Vic 3128

Alice Springs office
10 Wilkinson Street
Alice Springs NT 0870
Att: Tony Kress

Ph: (089) 530 229
Fx: (089) 530 324
Ah: (089) 524 440

Burdo 1 Well Site
Ph: (007) 114051
Fx: (007) 114052

NT Dept. Mines & Energy:

GPO Box 2901
Darwin NT 0801
Att: W.L. Tinapple (Bill)

Ph: (089) 895 511
Fx: (089) 895 530
Ah: (089) 270 425
Contract Drilling Engineers:

OZOIL PRODUCTION SERVICES
63 Christie Street
St Leonards NSW 2065
Att: Jim Slater

Drilling Contractor:

ROCKDRIL CONTRACTORS PTY LTD
Brisbane office:
1 Jijaws Street
Sumner Park QLD 4074
Att: Barry Clark

Mt Isa office:
9-11 Kolongo Crescent
Mt Isa QLD 4825
Att: Brad Majors

Drilling Fluid Services:

MILPARK DRILLING FLUIDS
43 Vincent Street
West Leederville WA 6007
Att: Lewis Arndt

Mudlogging Services:

HALLIBURTON DRILLING SYSTEMS
106 Marine Terrace
Fremantle WA 6160
Att: Anthony Watt

DST Services:

AUSTRALIAN DST CO. PTY LTD
Cnr Mitchell & Southern Roads
Roma QLD 4455
Att: Vern Sale

Wireline Logging Services:

SCHLUMBERGER SEACO INC.
PO Box 498
Roma QLD 4455
Att: Steve Capell
Laboratory Analysis:

AMDELL CORE SERVICES
31 Flemington Street
Frewville SA 5063
Att: Bob East
Robyn Tamke

CORE LABORATORIES
447-449 Belmont Avenue
Kewdale WA 6105
Att: David Manning

GEOTECHNICAL SERVICES PTY. LTD.
125 Burswood Road
Victoria Park WA 6100
Att: Brigitta Hartung-Kagi

Earthmoving Contractors:

MINEX PTY LTD
34 Strangways Road
Humpty Doo NT 0836
Att: Les Collins

Communications:

ITERRA
Ph: 008 032 578

Road Freight

KWIKASAIR
Ph: (089) 843755
Fx: (089) 472261

Tanumbirini Station:
Manager: Greg Campbell
Ph: (089) 759959

1.7 Iterra Co-ordinates

Azimuth: 54° 38' True North
49° 38' Magnetic North
Elevation: 58° 47'
Polarisation: -7°
2 DRILLING

2.1 Drilling Programme Summary

Full specifications of all drilling equipment including the BOPs are given in Appendix 1. The following drilling program is intended as a guide only. Any departure from this program will be notified immediately and approval sought from the Northern Territory Department of Mines and Energy.

- Prior to the arrival of the drilling rig a cellar will be prepared by the lease construction contractor.
- Rig up drilling rig (Rockdril #22) and using an auger prepare a 17½ inch hole to 1-2m below the cellar floor. Run and cement a 13½ inch conductor.
- Install flange and diverter on 13½ inch conductor.
- Make up 12¼ inch Bottom Hole Assembly, run in and drill 12¼ hole to approximately 60m with air and foam as required. Take survey at casing depth.
- Rig up and run 9½ inch deep conductor to approximately 60m and cement to surface using Class 'A' cement.
- Wait On Cement
- Install blooie line and rotating head.
- Make up an 8½ Bottom Hole Packed Assembly, run in the hole and drill out the casing shoe and cement.
- Drill ahead with air through the Jinduckin Formation, Tindall Limestone and 50m into the Antrim Volcanics taking surveys as per regulations.
- Rig up and run 7 inch surface casing to TD (±353m).
- Run two Cement Baskets at 50m and 40m and fit landing plate to last joint of 7 inch casing.
- Cement 7 inch casing with Class 'A' cement from 353m to 303m using 100% excess in open hole.
- Perform top up cement job from surface to cement baskets using Class 'A' cement.
- Wait on Cement.
- Nipple up BOPs and rotating head and pressure test blind rams.
- Make up a 6 inch Bottom Hole Assembly and run in the hole.
- Pressure and function test BOPs and surface equipment.
- Drill out float collar, shoe track, float shoe and cement.
- Drill 5m of formation and perform a leak off test.
- POH and make up air hammer and RIH with same, displacing fluid from hole as required. Hammer drill to ± 460m. POH and pick up rotary drilling assembly.
- Convert to polymer drilling mud system and continue drilling to TD, cutting cores and conducting DSTs as instructed. Take surveys as per regulations.
- Make wiper trip prior to running Electric Logs.
- Pull out of hole and rig up to run Electric Logs.
- Run Suite 1 Electric Logs including Velocity Survey.
- Following interpretation of Electric Logs the well will be further tested or plugged and abandoned.

2.2 Drilling Bits and Bottom Hole Assemblies

In order to minimise dog legs developing in the hole while drilling through the cavernous Tindall Limestone a packed BHA (including Jars) will be used over this section. The recommended bit and hydraulics programme is outlined in Appendix 3.
2.3 Depth Control

The drill pipe must be strapped out of hole prior to running casing, coring, testing or conducting logging operations.

2.4 Deviation Requirements

The deviation will be held to a maximum of 1 degree on the surface hole with surveys taken at 50m intervals and casing depth. Deviation thereafter will be controlled to a maximum of 5 degrees if possible, with surveys taken every 150m, on bit changes and casing depths. The maximum allowable rate of change of angle to be less than 1½ degrees per 30m.

2.5 Hydraulic and Mud Programme

A mud engineer will be on location to supervise the use of mud chemicals and maintain drilling fluid system at times when drilling is taking place using a fluid system. When using air drilling or an aerated fluid system an Air Drilling Specialist will be on location to monitor air and air/fluid mixtures and maintain the air drilling equipment.

Deep Conductor Hole - 12½ inch - 0 to 60m
This section is to be drilled with air and foam to clean the hole when necessary.

Surface Hole - 8½ inch - 60m to 353m
It is planned to drill this section (Jinduckin Formation, Tindall Limestone, Antrim Volcanics) with air. It is possible that large volumes of water and cuttings will be produced to the flare pit from this section. Drilling will continue to 50m into the Antrim Volcanics (identified from cuttings and/or ROP).

Production Hole - 6 inch - 353m to 1500m
The 6 inch hole will be drilled to approximately 464m, 50m into the Hayfield Mudstone, with air before changing to a polyacrylamide mud system. The polyacrylamide system will be used to drill from 464m to TD. Subject to hole conditions this mud may be lightened whilst drilling by the injection of air at the standpipe to minimise formation damage to potential producing horizons.

Mud Properties:-
Mud Weight : 7.0 - 8.6 ppg
Viscosity : 40 - 55 sec/qt
PV/YP : 10/18
WL : 5.0 - 7.0 cc/30min
pH : 8.5

2.6 Casing and Cementing

Deep Conductor

9½ inch OD - 0 - 60m

Run 9½ inch 36ppf K55 8rd LTC casing with a float shoe to 60m. Ensure that the first 2 joints and the float shoe are threadlocked at connections.
Centralise with one centraliser at 3m above the float shoe, one across the second coupling and one at approximately 10m KB.

Cementing:-

9½ inch conductor is to be cemented with 80 sacks of Class 'A' cement.

A preflush of 20 bbls fresh water is to be pumped ahead of the cement slurry.

A top rubber cementing plug is to be used and is to be bumped with 1000 psi maximum pressure.

WOC a minimum of 4 hours or until surface samples are set before slackling off the casing.

Cement Slurry Design:-

Cement : Class 'A'
Volume : 16.8 bbls (80 sacks)
Slurry Weight : 15.6 ppg
Water Requirement : 5.2 gal/sk fresh water
Yield : 1.18 cuft/sk
% Excess in OH : 50%
Thickening Time : ± 4 Hrs

Surface Casing

7 inch OD 0 - 353m
(Shoe to be set 50m into Antrim Volcanics)

Run 7 inch 29ppf N80 BTC casing with a float collar and guide shoe. All threads on the guide shoe, float collar and first two casing joints are to be threadlocked.

Centralise with one centraliser 3m above the guide shoe and one each across the second and third casing couplings. Install a landing plate on the last joint of casing to sit between the 9 inch casing and the lower edge of the last 7 inch casing collar.

Install cement baskets at 50m and 40m KB.

Cementing:-

Surface casing should be cemented with 45 sacks Class 'A' cement to achieve a 50m rise in the Antrim Volcanics from the shoe. Excess in the open hole will be 100%.

Cement Slurry Design:-

Cement : Class 'A'
Volume : 9bbls (45 sacks)
Additives : None
Slurry Weight : 15.6 ppg
Water Requirement : 5.2 gal/sk fresh water
Yield : 1.18 cuft/sk
% Excess in OH : 100%
Thickening Time : ± 3.5 Hrs
Use a bottom and top rubber cementing and bump the top plug with 1500psi maximum pressure.

Land 7 inch casing on landing plate, hook up cementing line to 2 inch inlet on the 9 1/2 inch casing stub and cement from top down to cementing baskets.

Install 7 inch x 9 inch Bradenhead. Nipple up BOPs and install diverter, blooie line and rotating head.

Production Casing

5 inch OD 0 - TD (1500m)

If evaluation shows the presence of significant hydrocarbons, a decision may be made to run production casing as follows:

<table>
<thead>
<tr>
<th>Interval</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface - TD 5 inch 13ppf FL4S</td>
<td>(casing yield strength of 4870 psi, anticipated maximum formation pressure 2320 psi)</td>
</tr>
</tbody>
</table>

Casing string should be run with a float shoe on the bottom joint and a float collar on the on the first casing coupling.

Production Casing Cement:

The cementing programme will be forwarded as soon as the necessary data from the wellsite becomes available. Cement requirements will be calculated once caliper logs are run and formation tops determined.

Circulate casing a minimum of 1 hour, or until shale shaker is free of cuttings. During circulation, reduce the YP to 5 or less with additions of water, and if necessary, small amounts of lignite. Casing to be reciprocated during cementing and displacement.

Casing Slips

Raise BOP stack and install Casing Slips. Land with casing weight from surface to expected TOC on slips. Rough cut casing 30cm (12 inch) above slips and lay out BOPs. Tackweld a cap to top of casing.

2.7 Safety Programme

2.7.1 Pre-Spud

Conduct a Pre-Spud meeting with rig personnel and service company personnel to outline the general drilling programme objectives, safety and responsibilities. An Occupational Health and Safety Officer will be nominated at this meeting and all injuries are to be reported to him/her no matter how minor.

Emphasise "SAFETY" in all operations.
BOP Equipment Pressure tested
a) On initial installation
b) Following any component change of repair
c) Weekly or at first subsequent opportunity

A suitable cup-tester will be available on locations and is to be used on all BOPs and related equipment tests.

2.7.2 **Pressure Control Equipment**

The blowout prevention equipment will be installed, maintained and operated in accordance with the Northern Territory "Specific Requirements as to Petroleum Exploration and Production - 1986" and standard oil field practice. In particular the following practices will be undertaken:

- **Annular Test** - Annular type BOPs shall be tested to 1000 psi following the setting of surface casing and prior to drilling out.

- **Ram and other BOP Assembly Tests** - Ram type BOPs and other related control equipment, including the choke manifold, kill lines, stand pipe and stabbing valve, shall be tested to 2000 psi following the setting of surface casing and prior to drilling out.

- All pressure tests are to be made with water unless otherwise specified.

- Pressures are to be held for at least 3 minutes at low pressure to identify leakage, followed by high pressure testing for a period as approved by the Drilling Supervisor.

- Drill out surface casing and 3m of new open hole with water and conduct leak-off test. Record results on tour sheet.

- Every seven days after drilling below surface casing depth, a pressure check of BOPs and manifold equipment will be made as above using a suitable cup-tester.

- Pipe Rams and annular Preventers are to be operated on a daily basis with Blind Rams being operated on each trip out of the hole.

- Slow pump rates are to be taken and recorded on tour sheets after drilling out of surface casing.

- Pit volumes must be carefully observed because the mud weights being used will have a minimal overbalance to formation pressures.

- Blowie line will be staked down and secured before air drilling commences.

- At least once every 7 days each crew will be exercised in a BOP drill. The drill and the response times will be noted on the daily log.

- A well kill work sheet will be maintained and updated each shift.
2.8 Formation Testing

Drill stem testing of any zone displaying encouraging hydrocarbon shows will be undertaken by Australian DST. A set of DST tools, to enable conventional bottom hole and bottom hole straddle tests, will be available on site. The DST engineer will be mobilised to site while running the 7 inch casing string.

All formation tests will be conducted following approval from the Northern Territory Department of Mines and Energy, and in accordance with the petroleum regulations and good oil field practice. A detailed testing programme will be provided prior to each test.

It is expected that reservoir units intersected in Burdo 1 will exhibit poor productivity. Hence all tests will be conducted initially as closed chamber tests with an inside, an outside and a recovery gauge. In addition a surface pressure read out gauge will be employed and monitored to prevent the hydrostatic head within the drill pipe killing the well. If the initial flow rate is exceedingly strong and it appears that the well will flow to surface the surface valve can be opened and a conventional DST conducted. Note it is important that all watches and clocks be set to Pacific's site representatives time and that a detailed log be kept of all events associated with the drill stem test.

The following procedure is given as a guide only:-

- Pull back to 20 m off bottom and circulate hole until clean.
- Wiper trip back to depth of last trip. Circulate hole clean, strap out of hole.
- Make up tester assembly, viz: bull nose, perforated anchor pipe, EMG carrier, packers, safety joint, EMG carrier, tester valve, CIP valve, EMG carrier. Check all measurements with testing engineer and ensure that the desired interval is in fact tested.
- Run in hole, (check flow line is clear and all valves, except for the surface valve are open).
- Make up flow head, steel hose and floor manifold (to include a fixed and variable choke, surface and pressure gauge) and connect to flow line. Do not use rig choke manifold.
- Ensure all sources of ignition have been suppressed.
- Set packer.
- Open valve observe annulus to ensure that packer is holding.
- During the flow period monitor the well via the surface pressure read out.
- After 5 minutes of initial flow, close the test valve.
- After an initial shut in of 60 minutes, open the test valve.
- During the final flow period monitor the well via the surface pressure read out. If the change in pressure divided by the change in time (dP/dT) begins to decrease end the flow period as this indicates the well is killing itself.
- If the surface pressure read out indicates potential for the well to flow naturally, open the surface valve and conduct the test as a conventional DST. Flow the well until all the drilling mud has been cleared. If the well is producing gas it should be flared. Pressure readings upstream of the choke should be made at regular intervals and flow rates estimated. Samples of gas and any fluid produced should be collected at frequent intervals from the flow manifold. If fluid has reached the surface establish the flow rate over at least one hour taking regular samples.
- When sufficient data have been obtained, close the test valve.
- The final shut-in period should be approximately twice as long as the flow period (preferably four times the flow period in tight formations).
- Consideration should be given to a third flow period with the surface valve open in order to maximise fluid recovery.
- Upon completion of the test, pull the packer.
- If there has been a flow of oil to the surface, or if it is suspected that there may be oil in the drill stem, reverse circulated after pulling the packer. Sample all recovered fluid at regular intervals.
- Pull out of hole. If the contents of the drill pipe have not been reversed out, take samples of the fluid (it is particularly important to collect a sample from above the CIP valve).

In order to limit formation damage it is imperative that drill stem tests be conducted as soon as possible following the drilling of the formation. If a significant hydrocarbon zone is suspected logs should be run as soon as possible following the drill stem test.

2.9 Produced Fluid and Cuttings Disposal

All drill cuttings will be transferred from the mud tanks to the sump where they will be buried at the conclusion of the well. All fluids produced on drill stem test will be flowed to the flare pit where any produced oil and gas will be burned. The station owner is to be notified. Produced water, which is likely to be saline will be evaporated with any residual salt being buried at least 1.5m below the ground surface. Drilling fluids will be dumped to the sump at the conclusion of the well, where it will be left to evaporate and the residual buried, at least 1.5m below the ground surface.

2.10 Abandonment

Following a full evaluation of the results obtained while drilling, from wireline logs, and from drill stem tests the well may be plugged and abandoned in accordance with the draft of the Northern Territory Schedule of Onshore Petroleum Exploration Production Requirements 1993. A final programme will be submitted to the NTDME for approval at the conclusion of the well and will incorporate the following:

- In the uncased portion of the well cement plugs shall be placed by displacement to provide a minimum of 30 m of cement above and a minimum of 30 m of cement below any significant oil, gas or fresh water zone.
- A cement plug placed by displacement from at least 30 m above to at least 30 m below the casing shoe, and to be verified by the application of weight.
- The fluid in the casing to be of an appropriate density and treated to inhibit corrosion of the casing string.
- A surface cement plug of at least 45 m in length is to be placed in the innermost casing string and to extend to the surface.
- A steel marker plate, one m above ground level and with the well name and total depth bead-welded onto it, shall be permanently fixed to the casing head or outermost casing stub.

2.11 Completion

In the event of encouraging hydrocarbon indications the well may be completed by the running and cementing of a 5 inch casing string. The casing programme will depend upon hydrocarbon indications in the well, with NTDME approval being sought prior to any completion being run.
2.12 General Notes

- Record KB to Ground Level on first morning report.
- Record KB to top of all casing spools on casing report.
- Wiper trips should be run to shoe/surface before running casing or logging. A 10 stand wiper trip may be sufficient before casing or testing, dependent on hole condition at the time.
- Condition mud and hole prior to electric logs.
- Should the geologist require a sample to be circulated, circulate 10 minutes on bottom before pulling 1 joint of drill pipe and continuing to circulate bottoms up (this will prevent the washing out of a potential DST packer seat).
- Tripping the drill pipe should be at a speed to prevent swabbing or surging the hole. Induced losses caused by formation breakdown must be avoided.
- Standing Procedures as set out by Kelly Down Consultants Pty Ltd including Emergency Response Plans and Safety are to be strictly adhered to.

3 FORMATION EVALUATION

3.1 Sampling

All sampling will be undertaken under the supervision of Pacific's site representative.

3.1.1 Cuttings Samples

0 - 353m
Where returns can be collected lag corrected samples will be collected at 5m intervals. Two samples each consisting of 200 gms will be collected, lightly washed and dried. One set of samples will be dispatched to the NTDME, and the other retained by Pacific Oil & Gas.

353 - 1500m
Lag corrected samples will be collected at 3m intervals. Two samples each consisting of 200 gm will be collected, lightly washed and dried. One set of samples will be dispatched to the NTDME and the other retained by Pacific Oil & Gas.

3.1.2 Core Samples

Cores may be spotted anywhere where significant shows and increases in cuttings gas are encountered.

Representative chip samples will be taken from the cored intervals. The chip samples will be retained by Pacific Oil & Gas.

3.2 Mudlogging

Mudlogging services will be provided by Halliburton Drilling Systems. The mudlogging personnel will be responsible for the following:

- To monitor ROP, total gas, gas chromatography, pit level and drilling parameters.
- To catch, wash, describe and evaluate all drill cuttings.
- To record the above along with bit data, mud data, DST data, etc., on a Mudlog.
- To assist the well site geologist in core handling, marking, description and despatch.
- To assist the well site geologist during well testing by taking appropriate samples when instructed and marking them appropriately.
- Other such tasks as from time to time may be required.

3.3 Wireline Logging

353 - 1500m

Schlumberger Seaco have been contracted to run the following total depth logs
DIL-BHC-GR-CAL (TD to casing shoe)
LDL-CNL-GR (TD to casing, GR to surface)
SAT (20 shots)
- If no DST’s have been conducted an RFT with quartz gauges may be run to obtain pressure data.
- If encouraging hydrocarbon shows are encountered the BHC will be replaced with an Array Sonic tool to recover full wave form data.
- An FMS log will be run over reservoir section if encouraging hydrocarbon shows are intersected.
- All logs are to include a 50m repeat section.

The velocity check shot survey will be planned following a review of the wireline logs. Geophone locations are to be chosen at selected formation tops, significant sonic velocity changes or every 150m, whichever is less.

3.4 Drill Stem Testing

Closed chamber drill stem tests will be run over any zone containing hydrocarbon shows which may flow. In order to minimise formation damage drill stem tests must be run as soon as possible after drilling the formation, requiring the DST engineer to be mobilised to site prior to intersecting the target formation. Actual procedures for running DST’s are outlined in section 4.7 and in the Drilling Operations Manual.

4 GEOLOGICAL PROGNOSIS

The following is a brief description of the formations and lithologies expected to be intersected in the Burdo 1 well. Prognosed depths are below kelly bushing.

4.1 General Geology

Burdo 1 is designed to test the fracture potential of the Upper Roper Group Section at the top of a large seismically defined two way roll over. The structure is interpreted to be the result of significant strike-slip faulting which may produce a fractured environment, suitable for the entrapment of hydrocarbons. Fracture development is expected throughout the upper Roper Group section. Hydrocarbon is expected to be sourced from the organic rich mudstones of the Kyalla Member of the McMinn Formation and the Velkerri Formation. Burdo 1 will be the first test of this style of structure within the basin.

At the same time, valuable data on maturation source and reservoir quality of the sands will be obtained from this well, confirming or otherwise the hydrocarbon prospectivity of EP23.
**Burdo 1** will provide the only seismic well control in EP23, and the north eastern Beetaloo sub-Basin. The well control will greatly improve the confidence in seismic depth conversions in this region.

### 4.2 Seismic Depth Conversion

**Burdo 1** has been planned using a depth prognosis calculated from the migration velocities on the seismic section. This method results in the deepest depth prognosis and has been used to ensure adequacy of materials and equipment. Lack of well control in the area makes accurate seismic depth conversion impossible. Several methods have been used to produce depth prognosis to the top of the "Jamison Sandstone", estimates range from 342m to 480m G.L. The most favoured method, using migration velocities referenced to the basalt trend prognoses the top "Jamison Sandstone" at 459m G.L. From past experiences within the basin, each of these depth predictions can expect to have an error up to 10%. Increased well control in the future may decrease the size of this error.

Incorporating the 10% error into the various depth prognosis for the "Jamison Sandstone" at **Burdo 1** gives a range of depths between 313 and 533m (DF).

### 4.3 Stratigraphy

**Undifferentiated Tertiary/Cretaceous**

4.9 to 64.9 m (60.0 m thick)

Red, yellowish orange to white clay and poorly indurated claystone with minor silt and sand increasing towards base.

**Jinduckin Formation** (Cambrian)

64.9 - 203.9 m (139 m thick)

Off-white, light grey and locally brown/orange interbedded limestone with variable clastic component, mudstone - sandstone.

**Tindall Limestone** (Cambrian)

203.9 - 302.9 m (99 m thick)

Off-white, light grey and locally brown/orange limestone, fine to coarse crystalline, with variable claystone and sandstone.

**Antrim Plateau Volcanics** (Cambrian)

302.9 - 418.9 m (116 m thick)

Dark greenish to brownish grey, fine to occasionally coarse, crystalline basalt, locally altered and vuggy.
"Hayfield Mudstone" (Proterozoic)
418.9 - 484.9 m (67 m thick)

Greyish green to occasionally greyish brown (and rarely dark grey) mudstone, commonly silty, with infrequent intervals of finely interbedded/laminated sandstone becoming more common towards the base. Stratification is generally "massive" to poorly-defined planar lamination, becoming well-defined where sandstone interbeds/laminae occur.

"Jamison Sandstone" (Proterozoic)
484.9 - 574.9 m (90 m thick)

White to light grey (occasionally greenish), very fine to coarse quartzose sandstone with a pebbly conglomerate at the base and rare mudstone interbeds. Generally massive to poorly-defined bedding, with occasional cross-stratification. Mostly very silicified, with small intervals of moderate porosity and permeability containing hydrocarbons.

McMinn Formation - Kyalla Member (Proterozoic)
574.9 - 1155.9 m (518 m thick)

Medium dark grey to black mudstone and silty mudstone with intervals of variably interbedded light grey siltstone and sandstone. Stratification is dominantly planar to wavy planar with frequent (but sporadic) units of chaotic/slumped bedding and sediment mixing, all containing variably complete upward-fining cycles. Where regular interbedding of sandstone and mudstone occurs, dewatering (sandstone injection) structures, are commonly developed.

McMinn Formation - Moroak Sandstone Member (Proterozoic)
1155.9 - 1500 m (344.1 m cut)

White to light grey, very fine to coarse, quartzose sandstone. Generally massive to poorly-defined bedding with occasional cross-stratification. Mostly very silicified with small intervals of moderate porosity and permeability containing hydrocarbons.

5 ENVIRONMENTAL ISSUES

5.1 General

All activities conducted by Pacific in the drilling of Burdo 1 will be in accordance with the CRA Exploration Environmental Policy, which is included in Appendix 4.

The drillsite for Burdo 1 is located 25 km north-west of Tanumbirini Homestead (approx. 344 km south-east of Katherine) in country characterised by low relief. Vegetation in the immediate area is Eucalyptus dichromophloia (Variable - barked Bloodwood) low-open woodland with Chrysopogon fallax (Golden Beard Grass), Plectrachne pungens (Curly Spinifex). No flora or fauna of significance are recorded for the general area.

The site and access is located on Tanumbirini Station, a pastoral lease predominantly involved in cattle grazing.
No other wells, public utilities or any other structure lie within 150m of the proposed well. No historic sites are recorded in the general area and the well site is clear of Aboriginal sites. Clearance was obtained for previous seismic surveys.

The programme area is located in the semi arid climatic zone of the Northern Territory. This zone is strongly influenced by the summer monsoons to the north with 95% of rainfall occurring from November to April. Rainfall averages about 800mm per annum with rainfall on an average of 60 days per year.

5.2 Access

Access to the well site from the Carpentaria Highway will be via station tracks and then by an existing seismic line.

The seismic line which is required to be reopened and the station track will be prepared to permit access by road trains transporting the drilling rig and camp facilities. This will generally involve grading, sheeting (where appropriate) rolling and watering to prepare a surface capable of carrying the intended traffic.

5.3 Wellsite

Preparation will generally involve separate removal and stockpiling of vegetation and topsoil to enable easy retrieval during rehabilitation. Mature trees will be left standing where possible. Disturbance of topsoil will be avoided in areas peripheral to the wellsite. Sumps and pits will then be excavated and material removed separately stockpiled.

The campsite will be prepared in a similar manner to the wellsite. Pits of sufficient capacity to allow for deep burial will be provided for the disposal of refuse and sewage effluent. Waste waters will be conveyed to earth drains constructed to allow for rapid infiltration and evaporation.

5.4 Rehabilitation

At the abandonment of the wellsite and prior to rehabilitation detailed specifications for rehabilitation of the wellsite and access will be provided.

In general terms rehabilitation will involve:

- removal of all litter, rubbish and other wastes,
- backfilling of all pits, sumps, drains etc and recontouring disturbances,
- ripping of compacted areas to alleviate compaction and to allow for aeration and penetration by water,
- resprading of separately stockpiled topsoil and timber
- constructing water diversion structures on cleared areas and replacing any cleared timber.

6 OCCUPATIONAL HEALTH AND SAFETY

Pursuant to CRA Ltd's (Pacific's parent Company) Occupational Health and Safety Policy, Pacific will ensure all employees at the wellsite comply with legal and regulatory requirements and consent arrangements relating to health and safety and take into account best practice.
Pacific's site representative will ensure contractors engaged at the site comply with legal and statutory requirements and any directions given by regulatory bodies. The site representative will also chair weekly safety meetings for each shift. The electrical installations at the well site and camp site will be inspected to ensure compliance with safety standards. Drilling will commence when the NTDME are satisfied safety standards are adequate.

Any accidents and/or injuries whether or not a serious injury, will be recorded for reporting each month to the Northern Territory Department of Mines and Energy.

Where a person dies or suffers a serious injury:

(a) a report shall forthwith be made to an inspector of the NTDME, and

(b) a report in writing giving full particulars and all related circumstances shall be transmitted to the Director of the NTDME as soon as practicable after the occurrence.

KEYWORDS

Petroleum, Exploration

LOCATION

1:250,000 Tanumbirini SD5302 1:100,000 Tanumbirini 5865

DESCRIPTOR

This report outlines the details and procedures required to drill the conventional petroleum exploration well Burdo 1.
APPENDIX 1

Rockdril Rig 22 Specifications
ROCKDRIL RIG 22 SPECIFICATIONS

1. DRAW-WORKS

Cooper double drum type draw-works model 42" x 10" and 38" x 8" mechanically driven through powershift transmission - 350 HP.

- Main Wireline 1"
- Sandline Drum Wire 7/16"
- Pressurised Circulating Brake Water Cooled
- Parmac 122 Hydromatic Auxiliary Brake

2. POWER SYSTEM

2 Detroit - GM 8V92TA engines water cooled diesel, rated 410 BHP at 1800 RPM.

Engines are fitted with flame proofing as follows:

- Ingersoll - Rand Air Starter

3. COMPOUND CASE

Twin engine input, twin output, (drawwork/rotary and mud pumps) Hy Vo chain running on heat treatment sprockets, pressure fed lubrication to bearing and chains, 700 HP rating.

4. TRANSMISSION

Allison model CLT 5961 six speed automatic transmission with torque convertor, air shift control.

5. ROTARY TABLE

17½" Opening Cooper rotary table. Static rated capacity 300 tons. Rotation speed up to 350 RPM.

6. MAST

Rockdril model MT 10815-300 cantilever self standing type mast, designed and manufactured in accordance with API specification No. 4E, for drilling and servicing structures and Australian Standard 1.5 1250, A.S. 1554, A.S. 1163. Designed to break down into 2100 kg packages for easy transportation and raised by draw-work power.
• Clear Working Height 108 ft (32.94 Mt.)
• Static Hook Load 220,000 lbs (100 tons)
• Gross Nominal Capacity 300,000 lbs. (136 tons)
• Max. Wind Load (No Set Back) 115 M.P.H.
• Max. Wind Load (With Rated Set Back) 100 M.P.H.

7. CROWN

Suitable for 8 line string up consisting of:

• Two (2) 24" Diameter Fast Line Sheaves, Grooved 1"
• Three (3) 28" Diameter Cluster Sheaves, Grooved 1"
• Two (2) 14" Diameter Sheaves, Grooved 7/16" for Wire Line

8. RACKING BOARD

Adjustable racking board with capacity to accommodate 200 stand of 3½" D.P.

9. SUBSTRUCTURE

Swing up type substructure with 14 ft (4.27 mt) clear working height under rotary table.

• Setback Load Capacity 220,000 lbs (100 tons)
• Floor Length 20 ft (6.10 mt)
• Floor Width 15 ft (4.5 mt)

10. MUD PUMPS

One (1) Triplex mud pump driven via tail-shaft from rig engine compound through a 9 speed 14 series shift gearbox.

Make OPI, Model AWS 500, Rated Max. input 500 H.P.
Dressed with 4" plungers, Rated .98 Gals/stroke
Max. strokes 400, Pressure Rating 5000 psi plus @ 150 spm
Also available 3-½" plungers rated .75 Gals/stroke

One (1) Triplex mud pump driven by separate skid mounted 6V92TA Detroit engine via a 9 speed 14 series manual shift gearbox.
Make OPI, Model DG350, Rated Max. input 350 H.P.  
Dressed with 6" liners, Rated 2.94 Gals/stroke  
Max. strokes 120, Pressure rating 1450 psi  
Also available 4-½" liners rated 1.65 Gals/stroke  
Pressure rating 2600 psi

11. CATLINE WINCH

Hydraulic catline winch planetary gear type, mounted on Derrick Leg.  
Hydraulic catline valve at V-door opening.

12. HYDRAULIC CATWORKS

Hydraulic makeup and break out catworks at rig floor with control located at driller console.  
- Max. Pull for Makeup 10,000 lbs  
- Max. Pull for Breakout 20,000 lbs

13. AIR SYSTEM

Two 12 CFM compressors driven by engines crankshaft.  
One 50 CFM compressor driven by flame proof 3 phase electric motor.

14. TRAVELLING BLOCK

McKissick Model 663 Travelling Block with incorporated hook - 100 ton capacity No. 4 Sheaves 1" rope.

15. MUD SWIVEL

OILWELL PC-100 6¾" API Reg. L.H. thread/pin.

16. MUD SYSTEM

4 each Mud Tanks 17 cubic meter each complete with:  
- Section Manifold 6"  
- Mud Mixing Guns No. 8  
- Electric Mud Agitators No. 4  
- Brandt 8 Cones Desilter SE 8  
- Brandt Double Shale Shaker  
- Centrifuges "Gasmaster" Degasser
• 2 Mixing and Servicing Centrifugal Pump Type Mission 4 x 5
  Driven by Electrical Motor
• Discharge Manifold 3" - 5000 psi
• Rotary Hose 3" x 50' - 5000 psi
• 2 Vibrator Hose 3" x 8' Mounted on Each Pump

1 each Mud Tank 8 cubic meter complete with hydraulic agitator

17. MISCELLANEOUS

• 1 each Water Storage Tank 17 Cubic Metre complete with Electric
  Centrifugal Pump
• 3 each Fuel Storage Tank Approximately 34 Cubic Metres Total
• 1 each Complete Explosion Proof Lighting System
• 1 each Warehouse Barrack
• 1 each Workshop Barrack
• 1 each Dog House
• Pipe Racks

18. BOP'S EQUIPMENT

• 1 each Shaffer Spherical BOP's Flanged Bottom 9" - 5000 psi
• 2 Single Ram BOP's Type Shaffer Flanged Top and Bottom
  9" 5000 psi - No outlets complete with:
    • Blind Rams
    • 3½" Rams
    • 4½" Ram
    • 7" Rams
• 1 Koomey Accumulator Unit for BOP Control Type MA0800 -
  11SBB Complete with Control Manifold and Remote Panel
• Drill Adaptor Spool flanged Top 9" - 5000 psi W.P. with
  Two outlet 2½" - 5000 psi and 3½" - 5000 psi
• 1 each Choke Manifold 3" - 5000 psi Complete with No. 2 Adjustable Choke.
• 1 each Choke Line 3" - 5000 psi to connect Choke Manifold to the Drilling Adaptor Spool
• 2" x 6000 psi Chiksan for Kill Line.
• 3" x 6000 psi Chiksan for Choke Line.
• Adaptor flange from top of BOP to 10" 3000 psi rotating head.

19. SURFACE EQUIPMENT

• 1 each Set Made up of 2 x B.J. type "C" Pipe and Casing Tongs to catch 3½", 4¼", 6½", 9¼".
• Set of Slips and Elevator Capable Handle and Run 3½" D.P. 4¾", D.C. 6½", D.C. 5" Casing, 7" Casing, 9¼" Casing, 13¾" Casing.
• 1 each Drilco Hexagonal Kelly 4¼".
• 1 each Drilco Hexagonal Kelly 3½".
• 1 each Hydril Upper Kelly Cock
• 1 each Lower Kelly Cock.
• 2 each Safety Clamp for D.C.
• 2 each B.J. Tool Pusher Links 1¾" x 60
• 2 each B.J. Tool Pusher Links 2¾" x 72
• Necessary Cup Testers for 5", 9½" and 7" Casings.
• 1 each Circulating Head for 9½" Casing B.T.C. 8 round.
• 1 each Circulating Head for 7" Casing B.T.C. 8 round.
• 1 each Bowen Type "Z" Oil Jar OD 6½" - 46 NC.
• 1 each Bowen Type "Z" Oil Jar OD 4¾" - 38 NC.
• 3 each Bowen Fishing Magnet 10" OD, 7" OD & 5" OD.
• 1 each Baash Ross Type "E" Autoloc Safety Joint OD 4¾" - 38 NC.
• 1 each Circulating Head 3½" IF Conn. Complete with Halliburton Low Torque Valve.
• 1 each Bowen Series 150 Overshot 7-7½" SH.
• 1 each Bowen Series 150 Overshot 5-5½" SH.
• 1 each Extension Sub for 7-3/8" Overshot.
• 1 each Bowl for 7-3/8" Overshot.
• 1 each Servco Junk Mill 8-1/8" OD - 4-1/2" Reg. Conn.
• 1 each Servco Junk Mill 5-3/4" OD - 3-1/2" Reg. Conn.
• 3 each Bowen Reverse Circulating Junk Baskets Sizes 5-3/4" - 7-7/8", 11".
• 1 each Bowen Junk Sub 6-5/8" OD.
• 1 each McCullogh 4-7/8" OD Bumper Sub and Safety Joint.
• Overshot grapples to suit all Contractor supplied tubulars.
• 22" Auger to set surface conductor pipe.

20. TUBULAR EQUIPMENT

• 26 each D.C. 4-3/4" x 2-5/16", 3-3/4" Conn.
• 21 each D.C. 6-1/2" x 2-3/16" 46" NC Conn.
• 1500 metres of 3-1/2" D.P. Grade E 13.3 lbs/ft IF.
• 2 each Christensen Core Barrel 4-3/4" x 2-7/8" x 30", complete with Necessary Handling Equipment.
• Set of Necessary Rotary Subs to Run Contractor Equipment.
• 1 each Near Bit Stabiliser for 8-1/2" Hole.
• 3 each String Stabiliser for 8-1/2" Hole.
• 1 each Near Bit Stabiliser for 6" Hole.
• 3 each String Stabiliser for 6" Hole.
• 1 each String Stabiliser for 12-1/4" Hole.
• 2 each Security Roller Reamers 12-1/4" - 8-1/2".

21. CONTROL EQUIPMENT

• 1 each Flame Proof Stroke Counter.
• 1 each Martin Decker Weight Indicator Metric System Complete with National Type "G" Anchor System.
• 1 each Totco Drilling Recorder with 3 Pen Recording - Penetration - Weight and Pump Pressure.
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APPENDICES

A. Minimum First Aid Requirements to be maintained on Location.

B. First Aid Procedures.
SECTION 1.

1 GENERAL PROCEDURES AND RESPONSIBILITIES

1.1 General

The following parameters are a broad outline of what is expected of the Drilling Supervisor during specific wellsite operations and other routine matters related to drilling operations. The following sections attempt to be more specific in certain areas such as Well Control and Drill Stem Testing and especially procedures to be followed during emergencies. These are not specific procedures to be followed to the letter, but rather a basic outline which may be varied as dictated by particular requirements.

1.2 Pre-Spud

1.2.1 Office Responsibilities

When selecting a potential well site due consideration should be given by the project team to choosing a site such that the environmental impact will be minimised. Once the location is selected a site visit will be undertaken to assess the sites suitability, determine access routes and water supplies and to negotiate site access agreements with parties likely to be affected by the program. If the site is unacceptable the project team will be approached to consider an alternative.

All earth work specifications will be prepared by Pacific's Melbourne office with input from the Environmental Officer. The specifications will take into account the Drilling Contractors specifications, best possible environmental practice, and any particular requirements pertinent to that site. If required a conductor and cellar will be installed prior to the arrival of the drilling rig. The Head Office is responsible for contracting a suitable drilling rig, materials and sub-contractors. All contracts shall incorporate Pacific's contractual requirements for Occupational Health & Safety, Environmental Protection and Commercial Practice.

A Drilling Program will be prepared as soon as possible in conjunction with the above. The Drilling Program will include a summary of expected drilling operations, a mud program, a bit and hydraulics program and an evaluation program. Deviations from this program should be checked with Head Office and notified to the relevant Government bodies. All depths will be referenced to the Kelly Bushing. The air gap is to be provided by the drilling contractor and should be checked prior to spud.

Applications to Government Authorities such as "Notice of Intent to Drill" will be submitted as early as possible and should be accompanied by the Drilling Program. "Right of Entry" and nomination of "Person-in-Charge" forms are to be finalised as early as possible.

1.2.2 Supervisors Responsibilities

In most cases, the Supervisor will be on location some days before spud. He is to check the lease with the Toolpusher especially the substructure pad and location of sump and flare pits. Materials should be checked and liaison with Sydney Office carried out. Water sourcing and availability will be considered and attempts made to ensure an adequate supply prior to spud (including drinking water). A water sample will be collected and sent to nearest cementing Company Office for analysis prior to any future cement jobs.
TYPICAL LEASE LAYOUT

DISTANCES:
- Flare Pit - Well: 45m
- Flare Pit - Access Road: 25m
- Fuel Supply - Well: 45m
- Oil Storage - Well: 45m
- Air Package - Well: 45m
The diagram shows a site layout for the 1993 McArthur Drilling Programme Rig 22. Key features include:

- **Rig Pad**: Lightly sheeted and levelled. All vegetation from the rig pad should be removed.
- **Seismic Line**: 45m from the well centre line.
- **Water Bore**: 12m x 5m x 2m deep.
- **Rubbish Pit**: 12m x 5m x 2m deep.
- **Waste Pit**: 12.5m deep.
- **Compressors**: 30m from the rig pad.
- **Access Road**: 30m from the rig pad.

The diagram includes dimensions and distances, indicating the spatial arrangement of the site works.
1.3 Drilling

1.3.1 Rig Operating Condition

Drilling Supervisor should, as a minimum, made a daily visual inspection of the rig and components and, if warranted, advise the contractors representative of any items requiring attention. Under Mines Department Regulations, it is the operators responsibility to ensure the contractor carries out the operation and maintains his equipment in a safe manner as defined in the relevant Petroleum Act. The Drilling Supervisor should be familiar with all regulations pertaining to drilling operations in the relevant State or Territory and will be provided with a copy of such.

The Supervisor should also check up on and arrange remedial action as required on items such as desander/desilter and degasser operations, pit level indicators, water leaks (wasting or using excessive water), handling of drilling mud materials (excessive breakage, protection from adverse weather, etc.), continual clean up and proper disposal of waste around the rig and camp (i.e. empty mud and cement sacks, empty drums, worn out rig parts, old bit, etc.).

It is the Operators responsibility and the Contractors duty (per contract) that the area be kept clean and tidy at all times.

1.3.2 Operators Materials

The Drilling Supervisor shall ensure accurate records are kept on all operators equipment and materials on site, i.e. items received, items used and items remaining after well completion. He must ensure that proper handling, storage and inspection of all items. He shall closely monitor consumables and advise Sydney Office of any requirements in sufficient time so that they can reasonably be delivered prior to need.

1.3.3 Drilling Fluids

The Mud Engineer is responsible for construction and maintenance of a good drilling fluid system as directed in the well program. He shall perform daily detailed testing as required to evaluate all relevant mud properties and determine required mud treatments.

Extreme care must be exercised in building and maintaining a good stable mud system as this is one of the main components which determine a good well drilling operation. Poor quality muds can cause extensive delays and greatly increase the cost of drilling.

It is essential that complete and accurate records be kept on properties and additives for future reference, analysis and comparison.

It is still the responsibility of the Drilling Supervisor to have knowledge of, and control of, the mud system. The function of the mud engineer is to conduct tests, make recommendations and assist with preparation of the system. The Supervisor must be aware of and ensure rig crewmen follow proper procedures in the addition of various materials to the system and especially, that they follow the Mud Engineers directions.
1.3.4 Drilling with Air or Aerated Mud

The Air Drilling Specialist in conjunction with the Drilling Supervisor will be responsible for the maintenance of the designed air/aerated drilling fluid system. Monitoring of injected gas/air volumes and mixtures are to be continuous while drilling with air. At all times the regulations for Air & Gas Drilling of the Governmental Department in the relevant State or Territory will be observed and adhered to.

Warning Notices will be posted at the entrance to the drilling location during all Air/Gas drilling operations and will state the following:-

CAUTION
AIR DRILLING
IN PROGRESS

The Drilling Supervisor will have knowledge of and at all times be in control of the air drilling system. The roll of the Air Drilling Specialist is to carry out monitoring of equipment and mixtures and to regularly report progress to the Drilling Supervisor including recommending changes to the air or aerated mud system, if required.

Air drilling will be used in situations where an increased rate of penetration is desirable and an underbalanced column of air or aerated drilling fluids will enhance the drilling operation. Improved drill bit performance and better control through lost circulation zones also can be achieved using air drilling.

The compressors will be situated a minimum 45m from the wellhead and the air delivery line, if not buried, will be laid in an area that will be clear of both vehicle access and personnel.

Due to the nature of Air Drilling a separate section titled "Air Drilling Safety Checklist" is included in this manual.

1.3.5 Drilling Parameters

General drilling parameters are provided with each drilling program (Bit and Hydraulics Program). These are in the form recommendations which may be varied from, if conditions or circumstances require. Bit weights and RPM are given normally with a range of conditions. Wherever possible, the upper limits are to be followed to obtain maximum penetration. Volumetric requirements are stated to maintain a desired annular return rate with an operating pump pressure of approximately 80% of maximum at the end of the anticipated bit run. These conditions and the recommended bit nozzle size should be followed as near as possible. In no circumstances will the Program stipulate operating parameters outside of equipment specifications or which are contrary to accepted good oilfield practices, but our contract permits us to establish the procedures we desire within these bounds.

The drill collar, stabiliser, reamer configurations recommended are designed to control the deviation problems we have encountered in the past. These are depicted as numbers and the code appears in Fig 1.1 below. They should be adhered to wherever possible and not be altered in other than exceptional circumstances. Any change should be discussed with Sydney Office unless the inability to make contact will cause delay to operations.

The Supervisor is to ensure that while the bit is on bottom, the drilling
TYPICAL AIRFOAM BOP
STACK LAYOUT

- Grant Model 8086
- 20" Rotating Head
- 21-1/4" - 2000-R-73 Flanged Spacer Spool
- 21-1/4" - 2000-Annular R-73 Flanged Top & Bottom
- 21-1/4" - 2000-Ram R-73 Studded Top & Bottom
- 21-1/4" - 2000-R-73 Flanged Mud Cross
- 21-1/4" 2000-R-73 Flanged Spacer Spool
- 'A' Section R-73 Flanged
DRILLING FLUID DENSITY

Drilling with Aerated Fluid

Weighted Mud
Un-Weighted Mud
Water
Aerated Mud
Stable Foam
Air/Mist

SG PPG
3.0 25
2.4 20
1.8 15
1.2 10
0.6 5
0.2
parameters are maintained within the specific range at all times. (Drillers allowing bit weights to drill off and then adding weights is not an acceptable practice). If the automatic driller is not operating properly, the drillers job is to keep constant weight on the bit. Crew men should make frequent checks on pump strokes, etc.

If it is evident from surface indications, i.e. kelly bouncing, etc., the parameters are likely to damage bit life, etc., the Supervisor should alter same to minimise the condition. Parameters should revert to those specified when the condition ceases to exist.

1.3.6 Downhole Drilling Equipment

It is essential that a record be kept on the rig on all tools run into the hole at any time.

At the commencement of each well, the drilling crews should measure and calliper (O.D. and I.D.) each drill collar as it is put into the string. This record must be maintained throughout the well with corrections made as required to keep it up to date. All cross over subs, reamer, stabilisers, junk subs, jars, etc., must have all dimensions on record (length O.D. and I.D.) as well as position within the string. Other than in exceptional circumstances, no string tools are to be used with an I.D. less than will permit through passage of normal tools used (Survey instrument, free point indicator, etc.) through a routine drilling operation.

This information is essential in case of stuck pipe or other fishing jobs.

Any time there is a fishing job, it is will be the Drilling Supervisors responsibility to ensure an accurate data record is kept of tools run in the hole on each and every run. Regardless if there is a fishing tool expert on site, the Supervisor is required to oversee all make up of tools, operations while fishing, and breakdown and recovery of tools.

NOTE: The gauge of stabilisers and new bit reamers are to be taken prior to running in and on pulling out along with the hours for each run. This information is import to Sydney Office to evaluate performance and costs.

1.3.7 Deviation Control

The deviation will be held to a maximum of 1° on surface hole. Deviation will be controlled thereafter to a maximum of 5° with the maximum permissible angle of change to be 1° in 30 m (100 ft).

For surface hole, surveys will be run at 18, 36 and 54 m (60, 120 and 180 ft), and thereafter, every 60 m (200 ft). On intermediate or production hole, surveys will be taken every 150 m (500 ft) and bit change to 1,500 m (5,000 ft). If deviation problems have occurred, continue surveys every 150 m (500 ft) till it becomes apparent that deviation is going to stay within the specified parameters.

From 1,500 m (5,000 ft) to T.D., survey at every bit change unless problems have occurred.

Ensure hole conditions are suitable prior to surveys and that pipe is stationary for as little time as possible. If a survey is misrun, repeat as soon as practicable.
Surveys will be required at shorter intervals, to be advised, if deviation exceeds the above parameters.

1.3.8 Open Hole Logging

The Drilling Supervisor shall ensure the log unit is in position and ready to rig up at start of operation and the work area, i.e. catwalk, floor, etc., is clear of tools, etc., which may hinder operations. He shall ensure the operators have sufficient help to rig up quickly, safely and efficiently, while change out tools, if required, and while rigging down.

He shall ensure that the well condition is closely monitored throughout the operation with regard to possible well flow, etc. The Geological personnel normally observe and witness logging runs, however, the Supervisor is ultimately responsible for the hole and any subsequent fishing.

1.3.9 Other Procedures

The following sections as well as those above attempt to cover most facets of the drilling operation. However, the many varied conditions at Well-site mean an enormous number of procedures where only experience and common-sense will prevail.

1.4 Well Completion

1.4.1 Rig Release

Pacific Oil & Gas Pty Ltd's general policy will be that rig release will be a maximum of up to eight hours after the plug is bumped in the production string. If plugging and abandoning a well rig release will be up to two hours after the top cement plug is set.

If the rig is required for Completion operations, then Sydney Office will advise.

1.4.2 Clean-Up

The Supervisor, before leaving a completed well location, shall:-

1. Ensure all required paper work, i.e. well records, inventories, listing of equipment remaining on site, is completed and delivered to Sydney Office.

2. All operator equipment is cleaned up and stacked out of the way on the edge of the location.

3. The engineers shack is packed and secured ready for moving, i.e. all loose materials and equipment in bins or drawers, air conditioner removed (if required) and hole plugged, hoses and cables stored, doors locked or barred, etc.).

4. All supplies, mud materials, cement, etc., are stacked on pallets in a suitable manner to permit safe transport. Surplus equipment, such as wellhead valves, ring gaskets, downhole equipment items to be packed on pallets or in boxes to prevent loss or damage while in transit.
5. Explicit instructions are given to the contractors representatives regarding general clean-up and disposal of junk. All combustible materials should be dumped into flare pit and burnt. Non-recoverable drums, old bits, cut off drilling line, engine filters, scrap iron and timber, etc., are to be dumped into flare pit or sump where they can be covered when lease back fill occurs.

Any combustible camp refuse is to be burnt in the garbage pit before leaving and all other refuse to be put in pit - see Section 10.
SECTION 2.

2 BOP AND CASING PRESSURE TESTING

2.1 BOP Stack Tests

Regular tests of the B.O.P. Stack in service will be carried out, but as a minimum, upon nipping up, every seven days after drilling out the previous casing string and prior to any DST or coring operation.

2.1.1 3000 psi B.O.P. Stack

1. Pipe Rams : 3000 psi
2. Kill/choke lines and valves : 3000 psi
3. Bag type annular : 2000 psi
4. Blind rams : 3000 psi or casing test pressure (see Section 2.2)

(a) Tests 1, 2 and 3 to be carried out with a boll weevil or plug type tester landed in the wellhead. If a cup type tester is used or if the tests are carried out against a closed casing, restrict all tests to the minimum casing test pressure or stack rating above.

(b) Never conduct test #4 with previous casing string open.

(c) For 5000 psi stack contact Sydney office.

(d) Accumulator Tests: Without recharging, the accumulator capacity shall be adequate for opening or closing the hydraulically operated choke line valve, for closing or opening all ram type preventers and one bag type preventer around drillpipe. Thereafter, within a maximum recharge time of three (3) minutes the accumulator fluid pressure shall be adequate for opening again the hydraulically operated choke line valve, closing again one ram type preventer and one bag type preventer around drillpipe, and holding them closed against the rated working pressure of the preventers. Minimum recharge time from above condition with both air and electric pumps running should be in accordance with manufacturer's specifications. A note that this test was carried out (and results) must be made in the tour sheet. This test should be carried out every 30 days.

Notes on Testing

1. After all tests, all studded connections must be checked for tightness.

2. All pressure tests to be carried out with water.

3. All related pressure equipment (choke, manifold, kelly, kelly cocks, standpipe, etc.) has to be satisfactorily pressure tested.

4. The test pressure should be maintained for 15 minutes and the acceptable pressure drop over this 15 minutes period is 10% of the initial test-pressure, provided that the pressure remains constant for the next 5 to 10 minutes.
5. All pressure tests to be recorded on pressure recorder charts.

6. The opening/closing times and the volumes of hydraulic operating fluid required for the operation of the various stack components should be recorded during testing of the stack. These results should be compared with the normal opening/closing times and volumes required of the hydraulic system. Any major differences are an indication that the system is not operating "normally" and may require further investigations and/or repairs.

7. Accumulator tests (as described above) should be performed after repairs have been done to be accumulator system, i.e. bottles, bladders, pumps, etc.

8. **Functional Tests, Inspections and Precautions**

   The blind rams shall be operated each time the bit is pulled.

   Should any of the above tests indicate faulty equipment, this equipment must be repaired before drilling or any other operation related thereto is continued.

   Frequently, inspect tightness of flange bolts and clamps, particularly after pressure testing.

   Pump through kill and choke lines at regular intervals. Do not leave weighted mud in choke manifold and kill lines. Choke manifold valves to be operated regularly to ensure free operation.

2.1.2 **Routine Testing of the B.O.P. Stack**

After previous casing is cemented and the stack is nippled up, circulate choke and kill lines and the stack to water. Close blind rams if used and test casing and peripheral valve and flanges to 500 psi, using rig pump or cement unit. See section 2.2.

If a test plug is available proceed as follows:

1. Run in the following test assembly (from bottom to top): 1 stand DP or DC - CLOSED Hydrl Kelly cock - plug type tester-sub with hole - D.P. Connection to tester to be only hand tight. Make sure that side outlets on bottom flange are opened after landing the tester. Install circulating head and close outer choke and kill valves. Close hydrl and minimum operating pressure and test through D.P. to 2000 psi.

2. Bleed off, open Hydrl and close pipe rams. Test through D.P. to 3000 psi. Bleed off to 500 psi and open H.C.R. valve under pressure, if installed.

3. Open outer kill valve, close inner choke and kill valves and test through D.P. to 3000 psi.

4. Bleed off, unscrew running string from tester and pull it back. Close blind rams and test through kill line to minimum, of 3000 psi or maximum casing pressure.
5. Retrieve test assembly: allow water to drain from stack.

6. Testing of kelly - kelly cocks - swivel - rotary hose - standpipe - standpipe manifold can be done before or after B.O.P. test. Test pressure to be 2500 psi.

7. Testing of choke manifold - choke line - kill line may be done before the stack test (if feasible) in order to save time.

NB: If a test plug is not available, then cup tester must be used. Any test pressures are then subject to minimum casing test pressures.

2.1.3 Pressure Testing of Casing

Care must be taken to ensure burst pressures with allowable tolerances are never exceeded. During B.O.P. testing the pressure is taken by the casing if test plugs are not used, or when testing blind rams.

Casing is normally pressure tested when the cement plug is bumped. Pacific Oil & Gas Pty Ltd policy is never to exceed 80% of burst pressure of the weakest casing in the string.

Burst pressures for some grades of casing appear in Table 2.2.
Table 2.2: Casing Burst Pressures

<table>
<thead>
<tr>
<th>SIZE (ins)</th>
<th>GRADE</th>
<th>WEIGHT (lb/ft)</th>
<th>BURST PRESSURE (psi)</th>
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<tr>
<td></td>
<td></td>
<td>ROUND THREAD</td>
<td>BUTTRESS</td>
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<tr>
<td></td>
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<td>SHORT</td>
<td>LONG</td>
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<tr>
<td></td>
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<td>5</td>
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<td>4870</td>
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<td>5700</td>
</tr>
<tr>
<td></td>
<td>K55</td>
<td>15.0</td>
<td>5700</td>
</tr>
<tr>
<td></td>
<td>N80</td>
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<td>18.0</td>
<td>-</td>
<td>10140</td>
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<tr>
<td>5½</td>
<td>J55</td>
<td>15.5</td>
<td>4810</td>
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<td></td>
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<td>3060</td>
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SECTION 3.

3 WELL CONTROL

3.1 General

Well control is concerned with maintaining a safe drilling condition even if an influx of formation fluid has occurred. The key to control is quick, but calm action as the smaller the kick size the lower the pressures are to be dealt with. It follows that the sooner the kick is detected, the sooner the well can be shut in and the influx halted.

3.1.1 Contingency Plans

Contingency plans to cope with the possibility of kicks must be developed to prevent the possibility of the worst scenario - blowouts. Firstly, crews must be directed to the causes of blowouts.

1. Human Error.
2. Lack of Training.
3. Failure to keep hole full on trips.
4. Mud weight too low.
5. Lost circulation.
6. Swabbing or surging.
7. Faulty equipment.
8. Unexpected high pressure formations.

The development of a contingency plan must include:

1. Assigning Responsibilities - who will do what.
3. Adequate Number of BOP Drills to ensure crews are familiar with procedures at least once each week.
4. Post Maximum Allowable hold back pressures and control equipment positions in prominent positions.

There are four basic tasks to be considered:

1. **Rig Control**

   Includes the blowout preventer, pumps, draw works, and such other operations of the drilling rig as may be necessary. Rig control is obviously the job of the driller and any blowout control procedure should assign these operations to the driller.

2. **Mud Control**

   Involves the addition of barite for mud density increase, but also includes chemical additions to the drilling mud and proper operation of the mixing system and the mud degasser. It is assumed that mud control operations are the responsibility of the derrick man. He may be assigned additional help, but one man must be primarily responsible.
3. **Choke Control**

Includes the calculation of the proper pressure and time relationships as well as the correct operation of the choke, and monitoring of pump rate. The choke operation should be the best trained man on the drilling rig, from the viewpoint of blowout control. His job is not difficult, but he will be required to give procedural guidance during the well killing operation.

The suggested choke manifold layout during normal drilling operations is shown overleaf. (Figure 3.0)

4. **Supervision**

This is the final element of control during a kick situation. The Company Representative, in conjunction with the Rig Manager, should handle this department. There should be an understanding as to areas of responsibility between the two, arranged prior to a kick situation, so that confusion is minimised and conflicting procedures do not make more trouble.

3.1.2 **Primary Methods of Abnormal Pore Pressure Detection**

(a) **Mud Temperature**

Mud temperatures at pump section and at the flow line are to be recorded. Indicating thermometers can be made available for temperature checks. A plot of mud flow-line temperature versus depth may be maintained with adjustments made for lag time. An increase in flow line temperature gradient will be considered a warning about abnormal pressure is impending.

(b) **Penetration Rate**

Penetration rate is to be continuously recorded. The driller is to mark on the chart the depth of each connection and the depth at which major changes are made in bit weight and/or rotary speed. Average bit weight and rotary speed will also be recorded at the depth of each connection and at the depths at which major changes occur. The depth at which new bit Is run is to be recorded.

It will be necessary to rely heavily upon experience to determine if a drilling break is due to lithology or pressure changes. An increase in penetration rate after drilling 15 m (50 ft) of shale will be considered a warning. A marked or abrupt decrease in shale drilling rate followed by an increase in penetration rate will be considered a definite indication of abnormal pressure. No more than 15 m (50 ft) Is to be drilled after penetration rate increases if the increase Is preceded by a decrease.

In addition to the continuous record of penetration rate, a plot of penetration rate versus depth will be maintained by the mud logger. The plot should not lag more than 5 m (16 ft) behind total depth. As it becomes available, lithologic data will be recorded on the same log.
The "DCS" Exponent

The "dcs" drilling exponent for shales may, if warranted, be plotted versus depth to establish bit dulling trend. Departure from the normal trend toward lower values of "dcs" will be considered a definite indication that abnormally high pressure is present.

To be most effective, the exponent should be plotted for 3 m (10 ft) of shale drilled. When other parameters or drilling depths indicate the possibility that over pressure is being approached, every effort should be made to hold bit weight and rotary speed constant. Plotting of the "dcs" exponent could then be temporarily discontinued to permit more time for analysis of gross penetration rate and other indicators.

Shale Density

The mud logger may, if warranted, plot surface shale density versus depth. Every effort shall be made to effect measurements on clean shale samples only. All data obtained would be plotted on the same log on which penetration rate and lithology are displayed. Shale densities which fall above the gradually increasing trend line are to be considered a warning. A decrease in shale density will be considered a definite indicate that an abnormally pressured formation has been penetrated.

3.1.3 Secondary Method for Abnormal Pore Pressure Detection

(a) Connection Gas

An increase in gas from connection to connection can be indicative of a gradually decreasing overbalance. The mud logger will continuously monitor gas content.

(b) Gas Cutting

Although gas cutting per se is not an indicator of higher pressure, continued gas cutting while circulating can indicate that a complete bottoms-up circulation is advisable so that shale densities can be checked.

(c) Sloughing Shale

An increase in cuttings can be indicative of underbalanced conditions. Long shale silvers with curved surfaces can be expected if a shale interval is drilled underbalanced. Recovery of "ring-tail" shale in a core or otherwise can be considered an excellent indicator of abnormal pressure.

(d) Torque and Drag

If an underbalance of the order of 1.0 lb/gal. occurs, average torque and drag usually increase by an appreciable amount. However, in a long transition zone, increase may occur so gradually that the significance of changes may be masked. Also, changes in torque and drag may be due to factors other than increasing pressure.
3.1.4 Warning Signs of an Impending Kick

Warning Signs of a Kick While Drilling

1. Increase in flow.
2. Pit level gain or loss.
3. Drilling break.
4. Variation in pump pressure.
5. Erratic pump pressure.
6. Gas, oil or salt water cut mud.
7. Weight indicator increases.
8. Well flows with pump shut off.
9. Sloughing shale.
10. Size and shape of drilled cuttings.
11. Flowing temperature.
12. Chloride ion content of the drilling fluid.

REMEMBER...

Most kicks take place while tripping!

Warning Signs of a Kick While Tripping

1. Hole takes incorrect amount of mud.
2. Pipe won’t come dry.
3. Trip tank level increases.
4. Well flows with pipe stationary.

3.1.5 Planning for a Trip

Statistically, most kicks have occurred while tripping. There are two reasons for this:

1. Not pumping the correct amount of mud into the annulus to replace for the pipe that is being pulled;
2. Swabbing.

Both of these are due to human error. Drillers and crew must understand the importance of putting the right amount of mud in the hole.

A typical "TRIP SHEET" is attached (Figure 3.1) and must be completed prior to any trip out of the hole. These are to be checked by the Company Representative and crews trained in their application.

3.1.6 Flow Checks

The fastest way to find out if a kick is in the hole or if a high pressure formation has been penetrated is by conducting a flow check. The three conditions for a flow check are:

1. With the drilling string on bottom (after a drilling break, before tripping).
2. With the drill string part way out of the hole (unusual hole fill volumes).
### TRIP SHEET

**WELL NAME:**

**CONTRACTOR:**

**DATE:**

**DEPTH:**

**RIG NUMBER:**

**DRILL PIPE SIZE:** ins

**lb/ft:**

**DRILL COLLAR:** ID x OD (ins)

### CALCULATED DISPLACEMENT

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<tr>
<th>DRILL PIPE</th>
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<th>DISPLACEMENT</th>
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<td></td>
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<td>DRY bbl/ft</td>
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<td></td>
<td></td>
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<tr>
<td>STAND</td>
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<table>
<thead>
<tr>
<th>DRILL COLLAR</th>
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<td></td>
<td>DRY bbl/ft</td>
<td>WET bbl/ft</td>
</tr>
<tr>
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</tr>
<tr>
<td>STAND</td>
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<td></td>
<td></td>
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</tbody>
</table>

### No. STANDS IN DERRICK

<table>
<thead>
<tr>
<th>CALCULATED VOLUME (bbls)</th>
<th>ACTUAL VOLUME (bbls)</th>
<th>TRIP TANK LEVEL (ins)</th>
<th>STANDS IN HOLE</th>
<th>THEORETICAL DISPLACEMENT (bbls)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL:** bbls

**Note:** Fill hole continually whilst pulling collars.

### Reason for Trip

**DRILLER:**

**DRILLING SUPERVISOR:**
3. With the drill string completed out of the hole.

There are three main steps for conducting a flow check and they will have to be varied only slightly depending on how much of the drill string is in the hole. There are:

1. The pump/pipe movement must be stopped.
2. The hole should be filled completely.
3. The flow should be checked and recorded over a period of about ten minutes.

If the flow check takes place while tripping, the trip tank level should be recorded and then used to check for the amount of flow.

3.1.7 Slow Pump Rates (Reduced Pump Rates)

When a kick is being circulated and a well being killed, a slower pump speed is selected so that:

1. lower pressures are being worked with; and,
2. there is more time to react to a pressure increase or decrease.

It is normal practice to select a slow pump speed (above idle) for each pump and record the stand pipe pressure. Adequate time for pressure stabilisation should be given prior to recording on each pump.

One value of SPM versus the pressure is recorded every 150 m (500 ft) for each pump and recorded in tour sheet daily.

3.1.8 General Safety Consideration Before and During a Kick Situation

1. NO SMOKING.
2. Work in pairs.
3. Will gas masks be required?
   • does everybody know how to use them?
   • does everyone know where they are?
4. Steam or water down motor exhausts.
5. Ventilate sub and mud tank areas.
6. Consider shutting off electrical power, eg shale shaker.
7. Check motor kills.
8. Crew Safety Talks - positions and procedures for a "kick".
9. Whereabouts of kelly cock wrench.
10. Whereabouts of stabbing valve and cross-over sub.
12. Ease of closing upper kelly cock.

3.1.9 Problems that can Arise While Killing a Well

1. Communication - noise, confusion, etc.
2. Difficulty in making required mud weight quickly, ie two or three circulations may be necessary to complete the kill (after each circulation, shut in well and determine pressures, etc.).
3. Plugged Chokes - someone who is alert and knowledgeable must be on the manual choke at all times, with both DP and CP gauges available.
4. Problems forcing shutting in well, ie mechanical breakdowns, eg air supply problems, pump washouts, gauge malfunctions.

5. Lost circulation below high pressure formation.

6. Approaching the rupture point - go to low choke method when at 80% of the rupture point (See section 3.2.2).

NB: It is vital that a panic situation does not arise. Every attempt to shut in the well as quickly as possible shall be made. Once shut in, the kill plan and implementation of procedure can proceed smoothly.

3.1.10 Shutting In a Well

A. Procedures for Closing In a Well While Drilling

1. Call alert.
2. Hoist the kelly to the first tool joint.
3. Shut off the pump.
4. Open the HCR (or the manual valve if no HCR).
5. Close the hydril (annular).
6. Close the choke slowly - do not exceed the maximum allowable surface pressure.
7. Set the regulator valve on the annular.
8. Alert the Company Representative and Toolpusher.
9. Record shut in drill pipe pressure (SIDPP) and shut in casing pressure (SICP), repeat every few minutes up to 15 minutes or until they stabilise, whichever comes first.
10. Estimate as accurately as possible the pit gain in barrels - enlist the help of derrickman, mud man and mud logger.

NOTES:

1. The 'soft' shut-in method is used here and considered by Pacific Oil & Gas Pty Ltd to be the most desirable shut-in procedure.

2. Maximum allowable surface pressure is usually governed by the formation leak-off pressure (see below).

B. Procedures to Closing a Well whilst Tripping Pipe

Carry out the following procedure if the well starts flowing:

1. Install a lower kelly cock in the open position, then close it.
2. Install an inside BOP valve above the kelly cock.
3. Open the kelly cock and attempt to run pipe as near to bottom as safety will permit. Subsequent action depends on whether or not the string can be returned to bottom (see (a), (b), and (c) below).
4. If a significant flow continues, close in the well prior to taking further action.

An Inside BOP and a lower kelly cock must always be available on the derrick floor and be ready for immediate use.

(a) Procedure If the string can be returned to bottom:

If the string can be returned to bottom, carry out the following procedure:

1. Circulate out the influx over the choke without increasing the mud density.
2. If necessary, apply choke pressure to maintain constant standpipe pressure at uniform flow rate.
3. Condition the mud.
4. Consider increasing the trip margin (overbalance) or reduce the pulling speed to facilitate pulling out of the hole.

(b) Stripping-in drill pipe

With an inside BOP installed in the drillstring, stripping-in can be considered. Important points to note when stripping-in are as follows:

• Use of the annular preventer by itself is preferred (the ram type preventers then serve as a back-up).

• For stripping tool joints through an annular preventer, the packing element must be allowed to breathe slightly when a tool-joint passes through. Therefore tool-joints must be lowered very slowly and the operating pressures should be kept as low as possible at the point where slight leakage through the packing element occurs. Depending on the wellbore pressure, it may be necessary to use the annular preventer and upper ram type preventer in sequence.

• The pipe is tripped through the closed rams only whilst a tool-joint is being lowered through the annular preventer.

• The pipe body between the tool joints is stripped through the closed annular preventer whilst the ram type preventer is open. This operation should only be carried out if a second ram type preventer is available as a back-up. It should be noted that this alternative is very time consuming and the BOP operating unit is subjected to extensive use.

• The drillstring should be kept full.

• A mud volume equal to the closed-end string displacement should be bled off whilst keeping the annulus pressure constant until the bit reaches the influx.
• If a gas influx is experienced, compensation for pressure increases due to migration has to be provided in addition to the adjustments for pipe displacement.

• When the closed-end drillstring enters the lower density influx the fluid will be displaced into the annulus and will occupy an increased height. Therefore, the back pressure should also be adjusted to compensate for the loss of hydrostatic head due to the greater height of the influx.

C. **Procedure if the String cannot be returned to Bottom**

If the drillstring cannot be returned to bottom, consider circulating heavier mud to balance the surface pressures so that the well can be opened and the string run deeper. The procedure is as follows:

1. With the well closed, take readings of the closed-in drill pipe and annulus pressures and, using the actual depth of the bit, calculate the mud density required to bring the well under control.

2. If the formation strength at the shoe is adequate, kill the well at bit depth using the "Wait and Weight" method.

3. After control has been regained and, after checking and treating, the returns as required, the drillstring should be carefully run back to bottom.

If the well has been brought under control with the string a considerable distance off bottom, it will be necessary to reduce the mud density gradually down to a value near to its original one whilst running and circulating the pipe in stages to the bottom.

If it becomes necessary to bring a well under control with the bit off bottom, consideration should also be given to employing the volumetric method, i.e., keeping bottom hole pressure above pore pressure. If a migration rate of 300 m/hr (1000 ft/hr) or more is estimated, this may offer a more convenient method than attempting to kill the well at bit depth. Migrating gas can complicate the latter process. Providing that the formation fluid (gas) is migrating, the volumetric method becomes more attractive as the bit depth becomes less.

Note that if gas is allowed to migrate up the hole under control, the resultant pressures will be the same as if the gas were circulated out using the original mud density.

D. **Procedure if there is a Flow with the string completely out of the Hole**

If a flow occurs when the string is completely out of the hole, and it is not possible to run the pipe into the well:

1. Close the blind rams.
2. Monitor the closed-in pressure.
3. If migration is indicated, use the volumetric method.
If pressures are likely to exceed the maximum allowable pressure, other action may be required.

3.2 Methods of Well Control

When a kick is taken on and a well shut in, there are a number of different methods of circulating out the invasion and circulating around heavy mud to kill the well. Only the "Wait and Weight" method will be used by Pacific Oil & Gas Pty Ltd Petroleum as it results in the lowest annulus pressures and the well bore pressure are reduced more quickly in case maximum allowable casing pressure is exceeded. However, it is expected that this situation will not arise due to diligent attention to BOP drills.

3.2.1 Wait and Weight Method (Constant Bottom Hole Pressure Method)

This method is a one circulation method, whereby as soon as the well is shut in calculations are done to determine what mud density will be needed to kill the well. Kill mud mixing is begun immediately and the proper volume and density is made up. It is then pumped around the well so that the invading kick is circulated out and the well is killed at the same time.

Standard kill sheets are provided to rig personnel and a copy is attached here (Figure 3.2).

A. Procedure

In this method the well is shut in, pressures are allowed to stabilise and then calculations are made to find the final kill mud weight. This heavy mud is mixed in the tanks and then circulated around, so that the invasion is pumped out at the same time as the well is being killed. The actual procedures are as follows:

A. Complete the kill sheet and determine quantity and weight of kill mud required.

B. Mix kill mud as quickly as possible without creating panic. Observe SICP regularly. See *Note.

C. When the pump has settled at the kill speed SPM, adjust the drill pipe pressure with the choke to read the initial Circulating Pressure (it should be very close to it anyway).

D. Using the graph on the kill sheet, make the drill pipe pressure decline so that when the kill mud reaches the bit, the Final Circulating Pressure is showing on the drill gauge.

E. Using the choke, hold that Final Circulating Pressure constant until the kill mud is at the surface, at which time the well will be dead.

*Note:

*1. If the kick is gas, pit volumes and casing pressure will rise - either way, do not vary from the procedures.
**2.** Prior to pumping kill mud SICP may increase with time - this is not cause for alarm, but simply means the kick is moving up the hole. The speed can be calculated by the rate of change of SICP (see later).

**3.2.2 Low Choke Method**

This method is initiated immediately if a well cannot be shut in because pressures are too high in the annulus. It involves pumping as quickly as possible (pressure permitting) and mixing weight material at the same time, while holding as much pressure as possible at the choke. At least one circulation is made before attempting to shut in the well, after which repeated attempts are made until it is possible to shut in and return to the Wait and Weight method.

**B. Procedure**

The Low Choke Method is used when the well cannot be shut in because the casing pressure is too high. It is most important that crew members understand the procedures and also why it is used; when the well is being shut in, if there is too much pressure on the annulus, the Low Choke Method is initiated immediately. The procedures are as follows:

1. **Start Mud Pump**

   In this step, the pump is to be running as fast as pressures permit. The limitations on the pump speed will be:

   (a) the safety release valve set on the pump; and more importantly,

   (b) the maximum allowable casing pressure.

   If the casing pressure is too high and the choke is wide open, then the pump will have to be slowed down.

2. **Casing Pressure Close to the Maximum Allowable**

   In the Low Choke Method, the well has not been completely shut in at any time and, while circulating, the pressure being held on the annulus is not even the minimum needed to stop the invasion from the formation. Mixing weight material will eventually give us enough hydrostatic pressure to be able to close in the well. In the meantime, however, as much pressure as possible should be held on the casing, using the choke. As stated above, if the choke is wide open and the casing pressure is too high, then the pump will have to be slowed down. A margin of about 50 psi is probably a good idea as a safety precaution, to be held as a cushion in front of the maximum allowable (ie if the maximum allowable casing pressure is 800 psi, then do not go any closer than 750 psi).
3. **Mix Barite at 2 Sacks per Minute**

Mixing barite at a faster rate than this might be possible on some rigs, however, plugging of the bit because of unmixed barite being pumped down the hole is not a desirable situation. If mud hoppers will not handle the weight material, the sacks can be mixed at the suction, taking care not to let slugs enter the mud system.

4. **Save Mud**

When gas or invasion comes to the surface, it obviously should be diverted from the mud tanks, as will be the case of going through the poor-boy degasser. An increase in tank volumes will be the result of a gas kick rising and expanding, while a liquid kick will not change tank volumes as it rises. Either way, mud should be saved to as great a degree as possible.

5. **Complete at Least One Circulation**

It will probably be necessary to circulate at least once before the barite being added will have any effect. After one circulation, the pump should be slowed and stopped and then an attempt made to shut in the well with the choke. If the pressure is too high, return to rapid pumping and mixing immediately. If the pressure is under the maximum allowable, but is too high to use the Wait and Weight Method, continue with the above.

6. **When the Well Can be Shut In**

Let the SIDPP and SICP stabilise. (No longer than 15-20 minutes). Then prepare to commence killing the well using the Wait and Weight Method.

The advantage of the Low Choke is that it gets you out of a difficult situation, ie that of having too much casing pressure. The disadvantage of this method, however, is that, because things are happening too fast, people get confused and make mistakes.

1. **Early** detection of a kick usually means that the Low Choke Method does not have to be used.

2. Crew members must have a full understanding of how the Low Choke Method works and why it is being used.

### 3.2.3 Top Kill Method

This is a "last ditch" method and should never need to be used if proper surveillance and oil field practices are used. It is used if the drill pipe becomes plugged during a kill operation or if the drill string is out of the hole. Heavy weight mud or cement is pumped into the kill-line with the rams shut and the influx bull-headed back into the formation.
3.3 Loss of Well Control

(a) General

There are accepted standard procedures for the recognition and handling of loss of well control and blow-outs. These procedures include such items as:

- Control and Kill Procedures;
- Equipment Requirements;
- Authorities to be notified;
- Personnel and Equipment Safety.

N.B. Refer Section 11.3, Page 11.2
SECTION 4.

4 DRILL STEM TESTING

4.1 General

Drill stem tests are performed primarily for two reasons:

1. To determine whether a particular formation sand or section will flow and, if so, obtain a sample.

2. To obtain reservoir pressure and permeability data.

Drill stem testing, although hazardous, is considered acceptable in open hole, but for safety reasons subject to the following limitations:

1. The flowing period may be terminated at any time at the discretion of the Drilling Supervisor if, in his opinion, flows or flowing pressures become excessively high.

2. The length of the interval to be tested will not exceed 25 m (80 ft).

3. Maximum duration between setting/unseating packers is 24 hours and these operations should be planned to take place during daylight hours.

4. Hole condition should be good or a reasonable chance of success assured.

5. Hole gauge must be judged from mud logs and penetration rates (if logs have not been run) so that a suitable packer seat can be confidently selected.

6. Testing will be discouraged below under-pressured or lost circulation horizons and will be forbidden if any H₂S has been detected.

4.2 D.S.T. Tools

For typical D.S.T. tool combinations commonly used by Pacific see Plan PetNTcw. Explanation of individual elements follows:

4.2.1 Anchor Shoe/Bull Nose

Protects tools off-bottom and provides support for assembly.

4.2.2 Outside Recorder Carrier

This sub serves as the running case for the Bourdon tube (BT) and/or the electronic memory probe (EMP) mechanical pressure recorder. Installation of the recorder at this point in the tool string permits uninterrupted recording of pressure changes if plugging should occur in the flow passages through the tools. This pressure recorder is isolated from flow stream and records only pressure which exists between anchor and the formation.

Note that "outside" refers to pressure measurement outside the tool, ie "blanked off".
Figure 4-1
4.2.3 Downhole Pressure Recorders

Pressure Recorders are placed in the testing string to record subsurface pressures (and electronic gauges also record temperature) throughout the formation testing procedure. These are subsequently examined to ascertain several things, mainly to evaluate the formations potential to flow and to ensure the test was valid. Any number may be run to cross check and by placing them in various parts of the test string, problem analysis can be undertaken.

The standard configuration run by Pacific comprises three electronic gauges (outside, inside and bottom of chamber) with two mechanical gauges (outside and inside) run as backups (because of their negligible extra cost).

The "outside" gauge measures formation pressure outside the perforations, whilst the "inside" gauge measures formation pressure inside the tool. If no plugging of the perforations occur these two gauges should read about the same.

The bottom of chamber (also termed "recovery") gauge is placed just above the shut-in tool to record the pressure of fluid influx into the chamber during the test.

a) Electronic Recorders

The electronic memory probe (EMP) digitally records pressure and temperature with time. Devices used in the past have typically been of strain gauge type, rated to 5000 psia with accuracy of ± 2.5psi and 0-150°C ±1°C with data point recording frequencies adjustable down to 4 seconds. After retrieving the recorder at the end of the test the data is downloaded through an interface to a PC and can be readily printed in table and/or graph form.

b) Mechanical Recorders, Bourdon Tube (BT) type

Pressure recordings are made on either a black or white coated metal chart by a marking stylus attached to the end of the Bourdon tube. The base line or line of zero pressure is inscribed on the chart after it is inserted in the gauge. Well pressure is transmitted through a rubber diaphragm to fluid contained inside the tube. Pressure increase causes the tube to tend to uncoil, moving the stylus away from the base line on the chart.

The chart travels past the stylus at a constraint rate. It is controlled by a spring driven clock designed to withstand shock and high temperature. Clocks are supplied in various time ratings. The clock rating determines the time required for complete travel of the chart. A complete recording of pressure versus time is made in one passage of the stylus across the face of the chart with no overlapping.

The gauges are supplied in pressure ratings ranging from 1,500 to 20,000 psi. Accuracy is maintained by individual calibration, preferably before each job in the shop. The gauges are submersed in a temperature controlled bath and calibrated by a dead weight tester. Calibration curves are supplied with each gauge.
The BT pressure sensing element is constructed of alloys that minimise deviation due to creep and temperature. Each element is tested and calibrated under both temperature and pressure variable. A calibration table is used to convert direct reading of the chart from deflections in thousandths of an inch to psi and a temperature correction factor is applied as required.

4.2.4 Perforated Pipe

Fluid from the formation enters the anchor pipe during the test through perforations. These openings act as a screen in preventing entry of shale or other foreign particles large enough to plug the fluid passage through the testing equipment. Sufficient openings are provided so that no restriction to flow is created.

The perforated pipe must be strong enough to provide support for drill pipe weight necessary to seat open hole packers. It also supports the pressure difference which exists across the packers during the test.

The perforated pipe is available in various lengths so that variable test intervals can be achieved.

4.2.5 Expanding Packers

1. Weight Set

This assembly consists essentially of a telescoping mechanism which includes a rubber wall packer for sealing against the formation. The expanding shoe is a hard rubber sleeve used below the softer rubber packer to help prevent the packer from extruding, due to high temperatures and pressures.

The packer and expanding shoe are expanded laterally by partial weight of the drill pipe. As weight is applied to the packer, the compression of the expanding shoe rubber is limited by the controlled travel of the steel packer support which transmits the greater part of the packer load directly to the supporting anchor.

Because the expanding shoe supports only that particular part of the packer which tends to extrude over the packer support it is lightly loaded in comparison with its high strength. This feature, along with the limited extrusion of the packer rubber, allows both the packer and expanding shoe to return to shape readily when load is removed.

2. Pressure Set - see Figure 4.1 (c)

The inflate packer is set by rotation which drives the packer inflation pump. This is fed an annulus mud through the screen sub to prevent blockage. Bypass pipe is used to inflate the bottom packer simultaneously and a pressure relief system allows bypass once the inflate pressure has been reached. The seat is tested by pulling 5 - 10,000 lbs on the string prior to opening the tool.

4.2.6 Safety Joint

The Safety Joint is a compact sub for use in the drill stem testing string.
enabling retrieval of any tools above it.

The male and female parts of the left hand safety joint thread are locked together by a spline and lug arrangement designed to reduce the chance of accidental disconnection by the usual manipulations of the drill pipe during a test.

4.2.7 Hydraulic Jars

The jars provide a temporary resistance that allows the drill pipe to be stretched when pulling to free the stuck tools. Then the resistance in the jar is released, the pipe contracts providing the energy required to deliver the impact blow. This temporary resistance is provided by a hydraulic time delay in the jar. The resistance is released when the metering sleeve inside the jar moves into the by-pass section of the outer case, allowing the special hydraulic oil to by-pass rapidly. Time delay required to release the temporary resistance varies with the amount of pull applied to the tool, that is, a light pull will take longer for the resistance to release than a hard pull.

4.2.8 Inside Recorder Carrier

This running case positions a pressure recorder above the packer so that pressure is recorded directly from the flow stream. This recorder is useful in that a correlation between this recording and the blanked off gauge recording can be made to verify suspicion of plugging or other questionable events. The recorder is support in the centre of the running case and permits the formation fluid to flow through the case and around the recorder.

4.2.9 Tester Valve

- Hydraulic Valve - Baker/Australian DST
- Hydrospring - Halliburton

The tester valve prevents well fluid entering the drill pipe when running (or pulling) the testing tool string. The tool includes a by-pass valve which is mechanically connected to the tester valve. The by-pass valve provides fluid passage through the packer in addition to that provided around the outside of the packer when running in or pulling out the tools. A hydraulic time delay system in the tool provides a measure of safety by preventing the tester valve opening immediately if the tool stands up on an obstruction, allowing time to pick up the string. This system also allows the packer to seat before the by-pass closes and the tester opens.

The tester is opened by applying 15-20,000 lbs weight to the tool. The drill pipe is lowered, allowing this weight to be applied to set the packers and operate the Hydro-Spring tester after a time delay of 1-3 minutes. To close the tester, the drill pipe is picked up to remove weight from the tester. The mandrel will return immediately to the fully extended position, closing the tester valve and opening the by-pass.

4.2.10 Rotating Valve (Shut In Valve)

- Rotating Shut-in Valve - Baker/Australian DST
- DCIP - Halliburton

This valve is run above the tester valve and usually a drill collar spacer, and
provides a means of taking two closed-in pressures, each following a flow period. This tool also permits an alternative point for reverse circulation following the final closed-in pressure if required.

The tool has a sliding valve arrangement which is actuated by a coarse screw thread mechanism. Valve operation is by right-hand rotation of drill pipe. A locking jaw clutch is designed to prevent movement of the valve except when string weight is applied, which should occur only when the packer is set.

(NOTE: this valve is NOT run in inflate tests as string needs to be rotate to inflate packers).

The valve is run in the open position. When the tester valve is opened, hydrostatic pressure below the packer is relieved allowing the mud and formation fluid to flow into the drill pipe. After flowing the formation for a short time (typically 5 minutes), the rotating valve is closed for the initial closed-in pressure build-up.

At the end of the initial closed-in pressure period the value is opened by drill pipe rotation for the final flowing period of the test. Further rotation will close the valve for the final closed-in pressure. Still further rotation will open the valve for reversing should the impact reversing sub and pump out sub fail to operate. Opening the reverse circulating ports does not open the main tool valves or affect the fluid sample trapped in the sample chamber.

4.2.11 Impact Reversing Sub

The reversing sub is a device which allows removal of the test string contents after the test is completed. It is also used to circulate and condition the drilling fluid before pulling the test string. The sub is opened by dropping a bar from the bar drop sub at surface to shear a hollow impact plug in the impact reversing sub. The impact plug will withstand differential pressures to 10,000 psi, internally or externally, and provides a ½" - ¾" opening after the plug is broken.

4.2.12 Pump-out Sub

The pump-out disc reversing valve provides a 5/8" diameter opening for reverse circulating after the disc is ruptured. Approximately 1,200 psi differential pressure applied internally is needed to rupture the disc. Discs, however, will withstand externally applied pressure differential of up to 10,000 psi.

NOTE: Always place the pump out sub at least one single above the impact sub. The impact sub should be placed at least a single to a stand above the “rotating valve” or the tester valve in the case of inflate tests.

4.3 Optional Equipment

4.3.1 Anchor Pipe Safety Joint

This is simply a safety joint placed in the anchor pipe allowing all tools above it to be retrieved should the anchor pipe get stuck.
4.3.2 Dual Packer/Distributor Valve Arrangement (Halliburton only)

To improve the chances of a good packer seat, two open hole expanding packer shoes may be run in tandem. The distributor valve supplied by Halliburton only is used primarily to prevent the build up of excessive pressure between the packers when they are set. The distributor valve contains a spring loaded valve which allows communication from the inside of the test string to the annular space between the two packers. As the assembly is run in the hole, hydrostatic pressure opens the valve. The packers are then set in the usual manner and any fluid compressed between the packers is vented into the test string (below the tester valve).

When the tester valve is opened, the reduced hydrostatic head below the top packer allows the distributor valve to close under the action of the spring, trapping a portion of the original hydrostatic head between the packers. This portion can be set by altering the spring pre-loading at surface before the device is run, and is generally adjusted so that the total final differential pressure is shared equally between the two packers.
Figure 4-2

DST SURFACE EQUIPMENT & LAYOUT
4.4 D.S.T. Surface Control Equipment

The surface control equipment used for DSTs is shown schematically in Figure 4.2.

1. BAR DROP SUB

This contains the fluted bar which shears the pin in the impact reversing sub. To release the bar from the device the bar retaining pin should be backed out until it stops.

2. FLO TEE

The side port which allows exit from the test string is fitted with a 2" Weco Union thread half.

3. SWIVEL

The pressure balanced swivel is designed to be used in testing only when drill pipe is resting in the slips since this swivel is internally pressure balanced, rotation through the flat washer type bearing is easy. While the swivel is strong enough to pick up the drill pipe, it will not rotate with this load hanging on it.

NOTE: The Baker Swivel is above the elevators and as such need take no load.

4. MASTER VALVE

The internal components of the master valve are identical to those of the Lo-Torc plug valve. The body, however, is strengthened to allow the full weight of the test string to be supported without straining or binding the operating parts.

NOTE: This valve can be remotely operated usually with air.

4.5 Surface Pressure Read Out (SPRO) Equipment

A closed chamber DST is conducted in the same manner as a conventional DST with the exception that no attempt is made to flow any sample directly from the reservoir to atmosphere.

Instead a valve is placed at surface to convert the drill pipe into a "closed chamber". Additionally, an electronic pressure gauge is installed at surface to monitor the pressure in the chamber. Any gas influx into the chamber will pressurise it and liquid influx will act like a piston to compress any gas (including air) already in the chamber.

The surface pressure build up is recorded with an electronic pressure gauge element connected to the surface test manifold. The gauge signal is processed by a computer to provide a selected interval (i.e. 1 minute) print out of pressure, time and surface temperature.

4.6 Supervisor Responsibilities: DST

Supervisor shall remain at well site during entire operation and as a minimum be on the floor observing:
(a) Make up of tools and initial R.I.H. stage.

(b) Before reaching bottom, during head up and opening tool, during majority of flow period and while tool is being shut in.

(c) While heading down and start of P.O.H.

(d) During fluid recovery or while reverse circulating out liquids are required.

(e) While breaking down tools.

Supervisor shall ensure accurate tally and description as well as calliper ing of all tools run in hole and these shall be documented. Accurately check pipe requirements and space out for test interval. Ensure test is conducted in the proper manner, vis. flow periods as directed, samples collected, accurate data on pressures and flows. Ensure data is reported and recorded consistently. Ensure tester complies with requirements of data forwarding, etc., as below in Section 4.6.

4.7 Drill Stem Test Procedure

4.7.1 Before Running the DST Assembly

1. On the trip prior to running the DST, when the bit is in the casing shoe, make up the DST surface control equipment. All equipment will have been shop tested to 10,000 psi - check with tester. Lay down the equipment in one section ready for later use.

2. Drill string is to be strapped out of hole and compared with the board strap. Any discrepancies must be accounted for before proceeding.

3. Hold an informal meeting with all persons participating in the drill stem test outlining the sequence of operations, emergency procedures and individual responsibilities.

4. Check/Test the BOP Stack as per program.

5. Be sure that fire fighting equipment is operational and that all other safety equipment is in good order.

6. Inspect tools prior to making up. Ensure that all packers and seals are new. Prepare dimensions drawings of all tools to be run or have operator supply them.

7. Ensure that rotation valve is in the initial “Open” position. The rotating part of the tool may be marked with paint to ensure that it remains in the open position whilst making up.

8. A representative mud sample must be taken and complete mud analysis carried out. A 50 ml sample of mud filtrate must also be acquired for laboratory analysis.

4.7.2 Making up the Tool String

1. Carefully observe the making up of the tool string for correct positioning of tools, damage caused by mishandling, and make up
torque of fine pitch and tool joint threads.

2. Observe the loading of the BT pressure recorders. Ensure:
   
   (a) that the recorder element serial numbers have been noted;
   
   (b) the recorders are of the correct pressure and time ranges;
   
   (c) the charts are inserted without damage and the base line drawn.
   
   (d) the recorders are set up and running correctly;
   
   (e) the positions of the recorders in the tool string are noted against the element serial numbers.

3. Note the weight of the string below the tester valve (especially important in off-bottom straddle tests).

4.7.3 Running the Test String

1. If a water cushion is required, the casing fill-up line may be used, but should preferably be fitted with a flexible hose and short 1½” line pipe stinger to minimise air entrainment.

2. Every 20 stands of drill pipe perform a paper test to check for string leaks. The test will be aborted and leak found prior to recommencement.

3. Periodically, whilst running the test string, stop and observe the annulus level to check for surging.

4. The assembly should be run slowly to avoid this pressure surging on the formation.

5. If the string stands up, pick up immediately to avoid opening the hydro-spring tester.

   NOTE: In sticky hole, make sure the string does not take weight just prior to setting slips.

6. If a leak occurs in the string, start pumps and stab the inside BOP/stab-in valve immediately. The surface control equipment may then be safely installed, the impact bar dropped and the string reverse circulated.

4.7.4 Performing DST

1. Set packer(s) with 15-20,000 lbs weight (15-20,000 lbs and weight of string below tester valve). Note the time. The valve should open after 1-2 minutes, indicated by a clear jolt in the string. Observe annulus level for possible packer seal failure. Observe SPRO for increase in chamber pressure indicating flow. Plot pressure versus time.

2. Close the rotating valve by rotation of string after a 5 minute Initial Flow (IF) period, noting time. If a gas flow is suspected vent the chamber through a
critical flow prover recording time and pressure.

3. Open the rotating valve after initial shut-in period (see table below) by rotating tool, for Final Flow (FF) period. Observe SPRO for increase in chamber pressure indicating flow and plot pressure versus time. If surface pressure change is accelerating (i.e. zone is cleaning up) extend flow period, if surface pressure change is decelerating (i.e. well is killing itself) end flow period.

4. Close the rotating valve for the final closed in period. If gas flow is suspected vent the chamber through a critical flow prover recording time and pressure.

5. Unseat packers at the end of the final closed-in period and observe annulus. Keep annulus full of mud. Initially considerable losses may be observed until the mud filter cake is re-established on the tested formation.

6. Watch annulus mud at all times during the test as packers can “let go” at any time.

**Suggested Flow/Shut-In Times**

Based on initial closed chamber behaviour (surface pressure) and anticipated quality of test zone (high or low permeability).

<table>
<thead>
<tr>
<th>Closed Chamber Response</th>
<th>&lt; 0.2 psi/min</th>
<th>0.2 - 1.5 psi/min</th>
<th>&gt; 1.5 psi/min</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ANTICIPATED PERMEABILITY</strong></td>
<td>TIGHT OR BADLY DAMAGED ZONE</td>
<td>FAIR TO GOOD PERMEABILITY</td>
<td>EXCELLENT PERMEABILITY</td>
</tr>
<tr>
<td>Pre-flow</td>
<td>5 min</td>
<td>5 min</td>
<td>5 min</td>
</tr>
<tr>
<td>ISI</td>
<td>120 min</td>
<td>90 min</td>
<td>60 min</td>
</tr>
<tr>
<td>Main Flow</td>
<td>60 min</td>
<td>60 min</td>
<td>60 min</td>
</tr>
<tr>
<td>FSI</td>
<td>240 min</td>
<td>180 min</td>
<td>90 min</td>
</tr>
</tbody>
</table>
Rules of Thumb

Pre-flow: Never exceed 5 minutes except in the most permeable wells.

ISI: Never less than 60 minutes in good zones; never less than 90 minutes in poor zones.

Main Flow: Usually 60 minutes is adequate, but

i) extend if zone is cleaning up (i.e. surface pressure change accelerating),

ii) curtail if the well is killing itself (i.e. surface pressure change decelerating).

NOTE: In both situations closed chamber DST personnel should be instructed to inform the Drilling Foreman.

PSI: Never less than 1½ times the main flow time in ANY test; on poor tests never less than 3 times the main flow time.

4.7.5 Pulling the Test String

1. Once the packers are unseated and the hole stabilised, pull up out of the zone - adequate chiksans for flexible pipe should be provided prior to the test to achieve this without breaking out any pipe.

2. From flow data and any weight picked up in the string, determine whether the string should be reserve circulated. Refer Section 4.7.6.

N.B. String will always be REVERSE CIRCULATED AT NIGHT.

3. If pipe is pulled to "recovery", the annulus must be watched closely. "Wet" trip sheets must be completed prior to hoisting and the cause of any deviation from planned volumes must be checked and remedied.

4. Hoist slowly to prevent swabbing.

N.B. String should NEVER be pulled if there is any suspicion of hydrocarbons being present.

4.7.6 Reverse Circulation of DST Fluid Recovery

To ensure a complete and controlled fluid recovery following a DST without the inherent dangers of pulling a test "wet", the following procedures are to be adhered to.

By closing the choke manifold when shearing the knock out sub or opening the DCIP valve, the sudden drop of annular fluid is buffered. This reduces co-mingling of produced fluids and allows the pumps to keep up with the dropping annulus.

N.B. Once balanced, the choke can be manipulated to give controlled recovery.

Proceed as Follows:

1. Calculate the drill string capacity above the impact sub or rotating valve (whichever is used) and convert the volume to pump strokes at 100% efficiency.

2. Zero the pump stroke counter or have two men on the pumps counting strokes. Have the pumps lined up to the fill-up or kill line (should already be done). Do not close the BOPs.
3. Close in the choke manifold. Drop the knock out bar or locate the valve to circulating position.

4. Fill the hole with both pumps as the annulus drops. Watch the annulus at all times, adjusting the pump rate to keep the annulus full but not overflowing.

5. Open the choke and commence recovery. Control the recovery rate using the choke and collect samples from the bubble hose.

6. As the flow slows down due to hydrostatic balancing, shut in the annular preventer and pump out the remainder of the recovery. Ensure the pump pressure (200-300 psi max.) does not exceed formation breakdown pressure. Circulate long enough to ensure all formation fluid has been displaced.

Return fluids will normally be diverted into a holding tank where volumetric recovery is confirmed and after a settling period, variable fluid recoveries are accurately determined.

7. Prepare a barite slug and spot in the usual way. The pipe should then pull dry.

8. More fluid samples may be drawn off between impact sub and rotating a tester valve (usually collected via drain hole).

9. Retrieve the pressure recorders making sure all information is marked on charts. Analyse fluid samples as required.

4.7.7 Water Cushion

The purpose of a fluid cushion is twofold.

1. Reduces the differential across the packers when the drill string is opened to atmosphere.

2. Cushions any "shock" the equipment receives upon opening.

Water cushions will be used for the above and at all times when the differential exceeds 4,000 psi. The height of cushion is calculated so as the maximum is not exceeded. In other cases liaison with the Drilling Department office is required as in many cases the decision may be judgemental.

4.7.8 Safety - Drill Stem Testing

Strict safety standards as per Pacific Oil & Gas Pty Ltd Operations and Emergency Procedures Manual and relevant authorities are to be adhered to at all times. A test will be terminated at any time at the discretion of the Pacific Oil & Gas Pty Ltd Drilling Supervisor if in his opinion safety is compromised. No pressure to continue an unsafe practice will be brought to bear by any other personnel.

Some other points are detailed below, but in no way cover every aspect of the operation; experience and common sense are needed.
SECTION 5.

5 CORING

5.1 General

Cores are taken in order to measure accurately the reservoir parameters in hydrocarbon and water bearing formations and for geological purposes, e.g.:

(a) "Porosity" samples, for measurement of porosity, permeability and grain density.

(b) "Saturation" samples, for measurement of porosity, permeability, oil and water saturation and grain density.

After description of the core, it is despatched as quickly as possible for analyses. The analyses comprise the determination of porosity, single-phase permeability, formation resistivity factor, mercury capillary pressure, toluene/air imbibition.

The following procedure should be adhered to in all cases where a drilling break and good hydrocarbon indication are found, proceed as follows:

1. Stop drilling and observe for flow.
2. Circulate bottoms up and determine hydrocarbon indications (both in mud and cuttings; gas readings).
3. If hydrocarbon indications are good, geology may decide to core.
4. If indications are poor, drill another 3 m (10 ft) and repeat items 1, 2 and 3.
5. If indications are still poor, continue drilling ahead, unless otherwise advised by base.

* good hydrocarbon indications:
  • good fluorescence;
  • strong gas shows;
  • oil in mud.

5.2 Tools

The inner core barrel is usually transported inside the outer barrel accompanied by the core heads and core barrel tool box.

1. Checks should be made by the Drilling Supervisor to determine whether adequate spares are being carried by the relevant coring Contractor.

2. Ensure tool box has necessary handling tools.

5.3 Coring In 12¼" Hole

Rat hole coring may generally be started from a 12¼" hole using a 60 ft core barrel providing one 12¼" stabiliser is installed directly above the core barrel and a second 12¼" stabiliser 18 m (60 ft) above the first.

If coring is to commence in hard formations, consideration should be given to running a 9 m (30 ft) core barrel initially.
On subsequent cores, the 12¼" stabilisers should be kept in their original locations and 6 x 6¾" drill collars added below them as required to space out for the Rat Hole. The drill collars in the rate hole should be stabilised every 18 m (60 ft).

5.4 Coring In 8½" Hole

On the bit run before coring, full gauge stabilisers should be installed in the bottom hole assembly (if not already done) to ensure that the core barrel may be run to bottom without significant reaming. A junk sub should be included also and worked prior to POH. A Drilling jar should be included in the drilling and coring assemblies. Reaming with a core barrel must be avoided. If it has to be done, however, the maximum circulating rate with minimum weights should be used whilst rotating at a maximum of 30 rpm.

5.5 General Notes on Coring

If the pump pressure goes up and torque decreases, it is an indication of a formation change.

If the pump pressure, penetration rate and torque decrease simultaneously, it is an indication that the core has jammed.

If the pump pressure and torque increases simultaneously, an O-Ring groove has developed.

When spacing out the inner barrel, up to ¼" too high can be accepted when coring hard formations.

When coring soft formations, spacing out should be as exact as possible.

Always have universal slip and dog and soft formation catchers available.

Always check the on-bottom/off-bottom circulating pressure, with both diamond core heads and drilling bits.

Space out the string, with pup joints if need be, to have a full kelly up whenever a core barrel is run in to bottom.

5.6 Coring Point Criteria

The decision to core is made geology and usually will depend in part on:

1. The prognosis of the top of the formation to be cored as given in the well program.

2. An increase in penetration rate on entering the more porous reservoir to be cored.

3. An increase of hydrocarbon indications when formation is hydrocarbon bearing. This is of course related to the penetration rate, since the amount of hydrocarbons released is dependent on the rock volume drilled.

4. In case of a sandstone reservoir, the appearance of the first individual sand grains, gradually increasing over the next 30 m (100 ft) to 50% and more. Particular care should be taken in the case of drilling with a diamond bit. The cuttings of such a bit tend to be completely crushed and resemble anhydrite. A sulphate test should tell the difference. In case of very tight formation, the cuttings are sometimes burned or cindered and bear no resemblance to the
original formation any more.

5. Gas or oil cut mud.

5.7 Core Handling

A. Preparations prior to Coring

The Drilling Supervisor should check with the Geologist that there are sufficient quantities on location of the following items:

1. Core boxes and lids. Make sure the lids are the same length as the boxes.
2. Rags.
3. Hammer and nails.
5. Tins with lids.
6. Aluminium foil.
7. Marker pens (black and red).
8. Core, Porosity and Saturation Labels.
9. Hydrocarbon solvent for “cut colour” and “cut fluorescence” tests.
10. Stapler and staples.
11. Scotchrap Tape.
12. Core description sheets.
13. 25 metal core trays (or old core boxes clearly marked Top and Bottom and numbered).
14. Wooden crates for transporting saturation sample tins (one box - 16 samples).
15. Standard Core Box, the inventory is specified in 5.6.7.

Make sure the following items are in working condition:

1. Ultraviolet lamp.
2. Can sealing machine.

Before actual recovery of the core, prepare boxes and labels as far as possible. Prepare the trays or boxes to collect the core from the core barrel on the derrick floor.

5.8 Recovery of Cores

The Drilling Supervisor shall ensure that geological personnel have sufficient aid in recovering the core, removing it from the rig floor, handling and cleaning it. Some notes on recovering cores are:

1. NEVER get hands in between the core and the floor.
2. See to it that the driller never lifts the core barrel more than 0.5-1 m (2-3 ft) above the derrick floor.
3. Transport the boxes after the core barrel has been emptied one by one to the place where they will be finally processed.
4. Make sure the core is adequately boxed, sampled and labelled.
5.9 Reporting

General

(a) All relevant data on coring must be reported on the daily drilling report.

(b) A summary of the core giving recovery figures, a general lithological description including hydrocarbon indications should be sent with copies to Geology.

(c) The mud logging contractor prepares a blank core grapholog just showing the lithological column.

(d) The core description should be sent in to the office as soon as possible.

5.10 Supervisor Responsibilities - Summary

Supervisor shall observe and ensure core barrel is made up correctly and that an accurate documentation is made of all tools and subs used, viz. length OD/ID, etc.

He is required to be on the floor prior to tool reaching bottom until coring is under way. He should be on the floor while connections are being made and is to be on the floor while breaking core and starting out of the hole.

He shall observe core recovery, servicing and laying down of core barrel. He shall ensure a complete record is kept of all the various parameters throughout the coring operation, and also ensure the geological personnel have sufficient aid in handling, cleaning and removing the core from the rig floor.

All core heads run in hole will be suitably logged including condition in and out.
6 FORMATION LEAK OFF TEST PROCEDURE

The purpose of the leak off test is to determine the maximum mud weight that can be used without fracturing the formation; or the maximum pressure that can be reached at the surface without losing circulation with a given mud weight.

The test will be conducted in the first 3-15 m (10-50 ft) of formation just below the previous casing string.

The procedure is to circulate the hole until there is a uniform mud weight throughout the down hole system. Close the pipe rams and pump very slowly at a constant rate. Record the pressures versus total volume pumped as below.

Procedure for the Conduct of a Formation Leak Off Test

1. Drill not more than 15 m (50 ft) below surface casing shoe.
2. Pull back into shoe and fill hole.
3. Circulate and ensure system is free of air - close BOP.
4. Start pumping slowly at rate of approximately 0.25 bbls per minute.
5. Record surface pressures as below.
6. Plot pressure against volume injected.

7. The point where the pressure plot ceases to be a straight line is the leak off pressure (LOP) and pumping at this point must be terminated to avoid fracturing the formation.
8. A rig mud pump is not suitable for performing a formation leak off test. Use the services of the contracted cementing company.
9. Calculate the Equivalent Mud Weight as:
   \[
   \text{EMW (ppg)} = \frac{\text{LOP (psi)}}{0.052 \times \text{depth (ft)}} + \text{Mud Weight (ppg)}
   \]
10. Report leak-off pressure as EMW and include the Pressure/Volume plot in results.
11. Complete the relevant form and return it to Sydney office.
**TABLE 6.1: FORMATION LEAK OFF TEST DATA**

Well Name:

Date:

Operator:

Testing Company:

Test conducted by:  

<table>
<thead>
<tr>
<th>Title:</th>
</tr>
</thead>
</table>

Size and Make of Pump used for Test:

- **Surface Casing Setting Depth:** .. ft.
- **Gradient of fluid in Hole during Test:** .. psi/ft.
- **Hydrostatic Pressure at Casing Shoe:** .. psi
- **Leak Off Pressure (surface):** .. psi
- **Total Pressure at Shoe:** .. psi
- **Formation Pressure Gradient:** .. psi/ft.
- **Projected depth to Production:** .. ft.
- **Maximum BHP expected:** .. psi
- **Gradient of Drilling Fluid to be used when penetrating Hydrocarbon Bearing Strata:** .. psi
- **Hydrostatic Pressure at Top of Production Zone(s):** .. psi

**Note:** Please include the Pressure verses Volume Plot with results when submitting Leak Off Test Data.
SECTION 7.

7 CASING AND CEMENTING

7.1 Nomenclature of Casing Strings for Land Wells

Conductor String

Used to cover unconsolidated surface formations; provides a circulation system for drilling fluid. The pipe is cemented to surface and usually set prior to rig moving in.

NOTE: As a general rule, conductor hole will be hand dug and set approximately 3-4 feet below cellar floor. If location is excessively sandy, the conductor hole will be drilled with an auger until a competent seat is found.

Surface String

Used to provide blowout protection; to seal off water sands and prevent loss of circulation. String is normally cemented to surface or inside conductor string.

Intermediate String

Usually set in transition zone of abnormal pressured formation and used to protect weak formations, to case off circulation losses, hole sloughing, caving, reservoir formations and to provide blowout protection. Cement fill to shut off hydrocarbon zones and flowing salt sections.

Production String

Used to separate the productive zones from other reservoir formations or for testing purposes.

Liner

(Other than production liners) used as an intermediate casing string to permit deeper drilling, to separate the productive zones from other reservoir formations or for testing purposes. Usually cemented to top of liner.

7.2 Preparations for Casing Running

7.2.1 General Notes

1. Clean and check casing threads and dope the female threads with the required lubricant, when pipe is on the rack. (Do not grease pipe in rotary table). Ensure that the protectors are backed off sufficiently to obtain the proper measuring point.

2. Accurately measure and drift casing on racks. The strap is the responsibility of the Drilling Supervisor and should be done twice for checking. The toolpusher should check as well.

3. Number joints and clearly mark lengths and mark joints to be excluded from string.

4. Indicate placement of centralisers and scratchers. Scratchers can be made up on racks, but centralisers are attached while running.
5. Check placement of cement shoe and collar. **Welding on casing is not permitted.** The collars of the joints making up the "Shoe track" should be removed and made up again with the proper torque and a thread locking compound should be used. Float collars and shoes should be made up similarly.

NOTE: Threadlock all joints to float collar ONLY.

6. See that sufficient water and mud is available and that adequate supply lines are provided for the Cementers.

7. Determine the amount of cement necessary from calliper survey or field experience.

8. Order cement materials in advance and notify the Cementers in time to have the cementing equipment rigged up prior to landing casing.

9. Have mud engineer check conditions of mud prior to pulling out of hole for casing (i.e. reduce yield point as much as possible).

10. Mud pumps should contain proper sized liners and be in good mechanical condition.

11. Have a mud fill-up line with a quick opening valve rigged up.

12. The hole depth must be checked by strapping out of the hole at least once prior to reaching a critical depth, such as casing point, logging point, etc., and, if these measurements do not agree, the pipe should be remeasured. Also check depth with Recorder in mud-logging unit.

13. If a liner is to be run, hook up lines for reversing and make sure that the amount of drillpipe on rack and in the derrick are known.

14. The Drilling Supervisor makes up the casing running program and has it checked by the Toolpusher. A copy is sent to Sydney Office as soon as is available by the quickest means possible. A running list is to be prepared stating exactly the joints to be run in and the joints to be left out. Copies to be handed to all personnel involved with running the casing, such as Contractor TP - Driller.

15. As soon as the landing joint is about to be run, the Drilling Supervisor shall count the amount of pipe remaining at that stage, and check it against the amount presumably in the hole and the total amount of pipe initially received on site. This is to ensure that the correct length of casing is run.

N.B. TD should be tagged with casing as an extra check. The joint may then be laid out.

16. **Position of Various Weights, Grades and Threads**

   The composition of the casing string is always given in the Drilling Program, or an addendum to it. The composition is designed by Sydney Office and should preferably be checked on the wellsite by the Drilling Supervisor.
17. **Cementing Depth TD Length of Rat-Hole**

When the casing depth is not exactly specified, this depth may be adjusted more or less to the available casing lengths.

A rat-hole is normally drilled to allow cuttings (forced down by the casing) or cavings not to hamper the running of the casing to its cementing depth and to allow for measuring and stretch "tolerances". The length of rat-hole is determined to allow the upper hole section to be adequately logged. Casing should be cemented as close as possible to bottom.

18. **Position of Float Collar**

Refer drilling program. Normally will be run one joint up.

19. **Stick-up**

To facilitate cement head handling, the stick-up, i.e. distance between rig-floor and top collar, should be as small as possible. Sometimes this is not possible, e.g. those cases where handling joints are not supplied.

20. Also check the following:

- **mud is in optimum condition**;
- excess mud resulting from cement and casing volume can be stored (do not empty tanks too far prior to running casing; mud losses may also develop during casing running);
- tank level recorders are working properly; mud level is measured;
- check cement water volume, condition salinity and Mg ++ content;
- cementation is calculated through and checked;
- cement samples have been approved;
- sufficient chase fluid is available;
- enough cement is available.

### 7.3 Checklist whilst Running/After Casing has been Run

#### Whilst Running Casing

Together with the Toolpusher, keep track of:

- installation of centralisers;
- pressure surges in the hole are avoided (do not run too fast and start pumps slowly);
- no joints are run that should be left out;
- check on any losses;
- no joints that should be left out are transported from the wellsites.
After Casing has been Run

Ensure that:

- casing is run to right depth (i.e. check joints that are left out);
- casing is circulated and reciprocation is started;
- mud is conditioned and properties are checked;
- hook loads whilst reciprocating up and down are recorded;
- pressures while circulating with intended displacement speed are recorded;
- cementing contractor (Halliburton or Dowell Schlumberger) are hooked up;
- sufficient space is available to receive the excess mud owing to cement and spacer volume;
- mud balance normal and true weight, etc., is available and in good condition;
- appropriate spacers are mixed;
- anti-foam agents are mixed in the cement water (only in salt water);
- everybody is in the picture and informed about cement properties desired;
- cement lines are pressure tested;
- stroke counters are pressure tested;
- sufficient mud is available to cope with possible losses;
- mud level in tanks is measured.

7.4 Casing Running and Cementing Operations

1. Visually check the inside of each joint of casing on rack to determine that all joints are clear of foreign materials.

   Shoe and collar may be made up on the racks (on separate joints). If the shoe track is shoe, 1 joint of casing and float collar, then all joints up to but not including the top of the collar are to be threadlocked.

2. On liner jobs, drift all drillpipe used with the required size "rabbit" and see that the rubber wiper plug is the correct size for the drillpipe. "Measure in" the string while running.

3. Place marker joints in the casing string as specified in drilling program.

4. Check conventional casing floating equipment and surface mud lines after shoe track is in.

5. Fill up casing every joint for first 10 or so joints and every 10 joints thereafter.

6. See that the casing is properly made up with the required torque.


8. Check the Cementers' hook-up. Cement unit and manifold stand-by for ready duty. Test and flush lines prior to cementing.

9. Visually check to be sure that the correct type bottom plug is property placed in the cementing head, prior to circulating the hole after landing casing.
10. See that a correct size shear pin or nail has been installed in rig pump relief value.


12. Circulate as per Drilling Program. Record pressures at ¼ and ½ of maximum circulation rate. In case of losses, the difference in pressure between circulating and displacing cement can still give a fair indication of top cement. The annular velocity around the casing should slightly exceed the maximum annular velocity used during drilling. In case of gascutting, circulate until a steady in/out mud weight is obtained. Regularly stop the pumps to allow entrained gas to percolate up. Do not cement until the well is completely static.

13. Release bottom plus with water and place top plug in cementing head, when employing one-plug-container head. Amount of water depends on hole conditions and hole size.

14. Mix cement to the required slurry weight and have cement weight checked regularly.

15. Catch samples of the cement slurry in numbered containers and at least 10 lbs of the dry mix and keep until results of the cement job have been determined. Also take water sample and record temperature when taken.

16. Leave mixing tub full of the proper required cement slurry at conclusion of mixing to avoid the possibility of pumping diluted cement or even water into the casing before the top plug is released.

17. Release top plug. Do not pump excess cement from lines on top of plug.

18. If rig pump is used, have Cementer’s pump unit ready to bump plug. Record all mixing - displacing - bumping, on charts. Pressure test casing immediately after bumping.

19. Release pressure, measure returns and check floating equipment.

20. If there is back-flow, pump back the amount of back-flow only and repressure the casing. If still back-flow, WOC till hard before repeating test.

21. If float equipment fails and/or pressure is held on the casing, every attempt should be made to manifold a pressure gauge into the system so that excessive pressure can be bled off. Note that this pressure should be maintained at theoretical differential between mud and cement.

7.5 Liners

Liner running procedure and tools will be advised from Sydney Office once the decision to run one has been made. The cementing program will be issued soon after.

7.6 Pressure Testing of Casing

After bumping of plug the casing should be pressure tested according to the testing procedure as laid down in Section 2.
7.7  Welding Procedures for Casing and Casing Heads

The following procedure is a direct extraction from the current API standard.

It should be noted that field welds under adverse conditions are difficult to control. In no case do the equipment suppliers accept any responsibility for determining or administering any field welding practices. The success of any field weld cannot be verified other than by subsequent hydrostatic test.

Any welding on casing should be discouraged and in the majority of cases will be unnecessary. Slip-on casing heads are available in cases where surface casing hangs up or if proper space-out has not been carried out.

7.7.1 Introduction and Scope

The following recommended procedure has been prepared with particular regard to attaining pressure-tight welds when attaching casing heads, flanges, etc., to casing. Although most of the high strength casing used (such as N80) is not normally considered field weldable, some success may be obtained by using the following or similar procedures.

Caution: In some wellheads, the seal weld is also a structural weld and can be subjected to high tensile stresses. Consideration must therefore be given by competent authority to the mechanical properties of the weld and its heat affected zone.

1. The steels used in wellhead parts and in casing are high strength steels that are susceptible to cracking when welded. It is imperative that the finished weld and adjacent metal be free from cracks. The heat from welding also affects the mechanical properties. This is especially serious if the weld is subjected to service tension stresses.

2. This procedure is offered only as a recommendation. The responsibility for welding lies with the user and results are largely governed by the welder's skill. Weldability of the several makes and grades of casing varies widely, thus placing added responsibility on the welder. Transporting a qualified welder to the job, rather than using a less-skilled man who may be at hand, will, in most cases, prove economical. The responsible operating representative should ascertain the welder's qualifications and, if necessary, assure himself by instruction or demonstration, that the welder is able to perform the work satisfactorily.

7.7.2 Welding Conditions

Unfavourable welding conditions must be avoided or minimised in every way possible, as even the most skilled welder cannot successfully weld steels that are susceptible to cracking under adverse working conditions, or when the work is rushed. Work above the welder on the drilling floor should be avoided. The weld should be protected from dripping mud, water, and oil and from wind, rain, or other adverse weather conditions. The drilling mud, water or other fluids must be lowered in the casing and kept at a low level until the weld has properly cooled. It is the responsibility of the user to provide supervision that will assure favourable working conditions, adequate time and the necessary co-operation of the rig personnel.
7.7.3 **Welding**

The welding should be done by the shielded metal-arc or other approved process.

7.7.4 **Filler Metal**

After the root pass, how hydrogen electrodes or filler wires of a yield strength equal to the casing yield strength should be used. The low hydrogen electrodes include classes EXX15, EXX16, EXX18, EXX28 of AWS A5.1 (latest edition): **Mild Steel Covered Arc-Welding Electrodes** and AWS A5.5 (latest edition): **Low-Alloy Steel Covered Arc Welding Electrodes**. Low hydrogen electrodes should not be exposed to the atmosphere until ready for use. Electrodes exposed to atmosphere should be dried 1 to 2 hours at 500-600°F just before use.

7.7.5 **Preparation of Base Metal**

The area to be welded should be dry and free of any paint, grease, scale, rust or dirt.

7.7.6 **Preheating**

Both the casing and the wellhead member should be preheated to 250-400°F for a distance of at least 3 inches on either side of the weld location, using a suitable preheating torch. Before applying preheat, the fluid should be bailed out of the casing to a point several inches below the weld location. The preheat temperature should be checked by the use of heat sensitive crayons. Special attention must be given to preheating the thick sections of wellhead parts to be welded, to insure uniform heating and expansion with respect to the relatively thin casing.

**NOTE:** Preheating may have to be modified because of the effect of temperature on adjacent packing elements which may be damaged by exposure to temperatures 200°F and higher. Temperature limitations of the packing materials should be determined before the application of preheat.

7.7.7 **Welding Technique**

Use \( \frac{1}{4} \)" or \( \frac{5}{32} \)" E6010 electrodes and step weld the first bead (root pass): i.e. weld approximately 2 to 4 inches and then move diametrically opposite this point and weld 2 to 4 inches. Then weld 2 to 4 inches halfway between the first two welds, move diametrically opposite this weld, and so on until the first pass is completed. The second pass should be made with a \( \frac{5}{32} \)" low hydrogen electrode of the proper strength and may be continuous. The balance of the welding groove may then be filled with continuous passes without back stepping or lacing, using a \( \frac{5}{32} \)" low hydrogen electrode. All beads should be stringer beads with good penetration and each bead after the root pass should be thoroughly peened before applying the next bead. There should be no undercutting and welds shall be workmanlike in appearance.

1. Test ports should be open when welding is performed to prevent pressure build-up within the test cavity.

2. During welding, the temperature of the base metal on either side of the weld should be maintained at 250°F minimum.

3. Care should be taken to insure that the welding cable is properly grounded to the casing, but ground wire should not be welded to the casing or the wellhead. Ground wire should be firmly clamped to the casing, the
wellhead, or fixed in position between pipe slips. Bad contact may cause sparking with resultant hard spots beneath which incipient cracks may develop. The welding cable should not be grounded to the steel derrick or to the rotary-table base.

7.7.8 Cleaning

All slag or flux remaining on any welding bead should be removed before laying the next bead. This also applies to the completed weld.

7.7.9 Defects

Any cracks or blow holes that appear on any bead should be removed to sound metal by shipping or grinding before depositing the next bead.

7.7.10 Postheating

For the removal of all brittle areas in high strength steel casing, a post heat temperature of 1050-1100°F is desirable. It is recognised, however, that this temperature is difficult or impossible to obtain in the field and that the mechanical properties of the wellhead parts and the pipe may be considerably reduced by these temperatures. As a practical matter, the temperature range of 500-900°F has been used with satisfactory results.

7.7.11 Cooling

Rapid cooling must be avoided. To assure slow cooling, welds should be protected from extreme weather conditions (cold, rain, high winds, etc.) by the use of a blanket of asbestos or other suitable insulating materials. Particular attention should be given to maintaining uniform cooling of the thick sections of the wellhead parts and the relatively thin casing, as the relatively thin casing will pull away from the head or hanger if allowed to cool more rapidly. The welds should be cooled in air to 250°F (121°C) (measured with a heat sensitive crayon) prior to permitting the mud to rise in the casing.

7.7.12 Recommended Electrodes

Root Pass: Lincoln "Fleetweld 5P"

or "Fleetweld 5" 3.2 or 4.0 mm.

Remaining Passes: Lincoln LH90 4.0 and 4.8 mm
SECTION 8.

8 DRILLING PROBLEMS

8.1 Hole Problems

Hole problems most likely to be encountered are:

(a) Mud rings, balling of stabilisers, DC assembly and bit, when drilling long shale sections.

(b) Unstable hole, due to sloughing or spalling clays/shales causing caving.

(c) Wall sticking and losses due to high mud weight, sticking due to key-seats, hole bridging or packing off.

8.1.1 Trouble-some Formations

These formations may contain large proportions of claystones and unconsolidated clays and shales. When coming into contact with water, these "GUMBO" clays swell and slough into the hole. To minimise this sloughing, mud weights can sometimes be used which are high enough to counteract this effect.

The hydration and subsequent swelling of Gumbo clays will be reduced and retarded by the use of inhibitive drilling fluids.

- potassium/sodium chloride: restrict hydration;
- polymers, polyacrylamides: encapsulation of clay particles.

Older shales can have a more brittle nature and are often subjected to mechanical stresses and overpressures, causing spalling which results in caving of the hole. This type of hole instability can be prevented by a high mud gradient and low fluid loss of the mud.

The importance of solids control in these parts of the hole cannot be over-emphasised, and therefore all available solids removal equipment (shakers, desanders, desilters and centrifuges) should be used and be maintained at maximum efficiency. Smallest possible screen sizes should be used on shakers, without incurring excessive mud losses because of screen flooding.

The mud viscosity depends on the number and size (surface area) of suspended particles. Bentonite clays hydrate very easily, resulting in an increased surface area and inter-action between particles, and thus in a rapid increase of the viscosity. The ultimate effect of the particle interaction is the recombination into conglomerates - "mud rings". Therefore, the following points should be noted when drilling/working through these sections of the hole:

1. Obtain maximum annular velocities by using maximum possible circulating rates, combined with optimum lifting capacity of the mud and optimum flow profile.

2. SAPP can be effective in breaking these rings.
3. Increase the frequency of checktrips. Drill with reduced RPM if conditions permit.

4. When reaming large intervals, use minimum practical number of drillcollars and use minimum stabilisers.

5. If necessary, restrict the penetration rate in order to limit the generation of solids, to such a rate that the solids can be efficiently removed.

6. Allow adequate circulation time to clean the hole prior to pulling out for a round trip.

7. Always shut down the pumps slowly and gradually, to avoid aggravating hole problems.

8. If problems are experienced with severe gas cutting (or trip gas), especially in case of deep holes and small size drill strings, it may be necessary to circulate bottoms up after a round trip prior to drilling ahead. This avoids confusion in determining the difference between trip and influx gas.

**8.1.2 Tight Hole**

Usually the causes or contributing factors can be recognised as follows:

1. Drilling through long sensitive shale sections.

2. Mud properties not up to standard, i.e. shale inhibition, water loss, density, lubricity, rheology and lifting capacity, etc.

3. Insufficient annular velocity and insufficient circulating times to effect optimum hole cleaning and/or optimum mud conditioning and treatment.

4. Insufficient solids removal in the mechanical mud treating equipment, i.e. shakers, desanders, desilters, etc.

5. Insufficient attention to mounting problems.

**8.1.3 Causes and Discussion**

The causes may be: insufficient inhibition - mud weight - lubricity - or hole cleaning. All these factors are important parameters, and comparison should be made between wells without any problems and which parameters were changed leading to the deterioration of the hole.

Tight hole problems start in most cases whilst coming out of the hole. It occurs sometimes where fresh hole has been drilled, or formations above reacting to changing hole conditions. Constant or spot-like overpull is experienced in excess of the normal when coming out of the hole.

The overpull could be the result of balling up of stabilisers and drillcollars by formation not removed, or from squeezing formations.
It is important to realise that this situation could lead to stuck pipe. To prevent this, the Drilling Supervisor should make certain that free movement, rotation and circulation is maintained at all times.

Ensure that the hole below, when pulling out (or above when running in), is in a good shape so as to be able to go back there to regain rotation and/or circulation.

Balling up of drillcollars and stabilisers under continued high overpulls results in loss of circulation, swabbing and finally sticking the string. In such circumstances, run back to a good part of the hole, condition the mud, add lubricants and maybe weight up the mud.

Try again to pull out (or run it) if it is decided that nothing more can be done.

It is not possible to lay down hard rules which will successfully cover the wide variety of sensitive areas.

The following standing instructions should be adhered to at all times:

1. Establish normal drag, up and down, prior to and whilst tripping.

2. DO NOT continually overpull unless in spots only. In case the overpull is continuous and/or increasing immediately, install the kelly, circulate and REAM DOWN a few singles first. Condition the mud and strongly consider adding lubrication to the system. Try again to come out of the hole and do not hesitate to wait too long before installing the key and rotate/circulate out of the hole single by single.

3. Ensure free movement of the string below the tight hole area at all times.

4. Contact Sydney Office if no improvement can be achieved when trying to pull out again.

Raising the mud weight over and above the weight normally used in the area is a last remedy to apply and should be confirmed by Sydney Office.

**8.1.4 Stuck Pipe**

**General**

Most stuck pipe problems not mentioned above can be attributed to differential pressure sticking, or what is more commonly referred to as "wall sticking". The primary indication of wall sticking is very obvious, i.e. the pipe sticks while motionless and thereafter cannot be rotated, while full circulation at normal pump pressure can be maintained. Generally, these conditions occur while making connections or during a trip. It should be noted at this point that no drilled hole is absolutely vertical. This being the case, exerting a tremendous pulling force on the drill string would tend to align the pipe vertically and introduce the possibility of causing sticking above the original stuck point.
This sticking can take place in any interval where the hole is deviated even a small amount from the vertical. This is the reason to stick to the standard order pull slowly even when the hole is in good shape. Many preventive measures can be taken to minimize wall sticking.

The possibility of wall sticking is lessened by altering mud properties: decreasing the mud weight to lower the differential pressure is one method, but this is not always possible. Another method is by lessening the contact area between the pipe and wall cake. This depends upon cake thickness. For this reason, low filtration rates and minimum solids concentration are desirable. Materials that reduce the friction factor between the pipe and mud solids are also of value in minimizing wall stuck pipe. Chemical oil emulsion muds, extreme pressure lubricants (bit lube) and detergents are all beneficial.

8.1.5 Methods of Freeing Stuck Pipe

In spite of all precautions, stuck pipe still occurs. The problem then is to free the pipe or fish by one of several methods:

1. Working it loose, washing over, connecting over shot.
2. Reduction of hydrostatic pressure by spotting a column of fluid lighter than the mud in use, such as water or oil.
3. Application of a drill-stem test tool. In the case of a full string in the hole, pipe must be backed off first. The test tool is run in with open ended drill pipe below it. The string is latched on and when the DST tool is opened, the differential pressure is relieved, freeing the pipe.
4. Spotting of various fluids around the pipe, such as oil or oil base mud, invert oil muds, saturated salt water, acid, and special surface liquids (PIPELAX) added to crude oil, or diesel oil. For weighted mud, PIPELAX can be mixed with oil base muds corresponding to the weight of the mud in the hole. This would prevent the tendency of a short fluid column of less density floating up through the heavier drilling fluid.

After the fluid is spotted, the pipe must be worked. The best method is to put the pipe under compression by slacking off 10,000 lbs. below the weight of the pipe and then applying torque by turning the string at drill floor ½ turn per 300 m (1,000 ft). Release torque and pick up the 10,000 lbs. Repeat this cycle as necessary.

Most of the time, the pipe will come free on the compression cycle. It should be pointed out that working the string in tension or hoisting with over pull, the indicated weight of the string could cause the pipe to become stuck further up the hole due to wall sticking, key seat or dog legs.

1. Have mud in good shape.
2. Pull slowly out of the hole.
3. Reciprocate string continuously.
4. Do not circulate at one spot.
5. Prepare to make connections as fast as possible.
8.1.6 Drill String Back-off Procedure

Job Preparation

1. String should be worked as long as possible prior to rigging up to prevent the stuck point from moving up.

2. Obtain the following data:
   (a) Weight of string before sticking, as read on Martin Decker weight indicator (check if weight of kelly was included in this reading or not).
   (b) ID, OD and weight of drillpipe or tubing (thread coupled).
   (c) ID, OD and weight of drill collars.
   (d) Hole data: bit size, total depth, casing size and weight, depth of casing shoe.
   (e) Depth of drillpipe, drill collars, drilling bit.
   (f) Depth of jar, safety joint, overshot. Check if ID is smaller than ID of pipe.
   (g) Hole deviation.

3. Make a sketch of the string showing the above information.

4. Establish back-off depth based on Free-Point indicator measurements on or stretch test.

5. Calculate required left hand torque and pull:

   **LEFT HAND TORQUE:**

<table>
<thead>
<tr>
<th>Back-off Depth</th>
<th>Turns per 1,000'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drill Pipe:</td>
<td></td>
</tr>
<tr>
<td>From 0 - 1,220 m</td>
<td>¼ - ¾</td>
</tr>
<tr>
<td>(0 - 4,000')</td>
<td></td>
</tr>
<tr>
<td>1,220 - 2,745 m</td>
<td>½ - 1</td>
</tr>
<tr>
<td>(4,000 - 9,000')</td>
<td></td>
</tr>
<tr>
<td>over 2,745 m</td>
<td>¾ - 1</td>
</tr>
<tr>
<td>(9,000')</td>
<td></td>
</tr>
<tr>
<td>Tubing:</td>
<td></td>
</tr>
<tr>
<td>From 0 - 1,830 m</td>
<td>½ - ¾</td>
</tr>
<tr>
<td>(0 - 6,000')</td>
<td></td>
</tr>
<tr>
<td>over 1,830 m</td>
<td>¾ - 1</td>
</tr>
<tr>
<td>(6,000')</td>
<td></td>
</tr>
</tbody>
</table>

**PULL:**

Hook load to be applied is equal to Martin Decker reading prior to sticking (2a) minus buoyant weight of fish to be left in hole.

If Martin Decker reading is not available, the hook load to be applied is calculated as the buoyant weight of the pipe from the surface to back-off.
6. Check that tong and slip dies are sharp and of correct size to hold pipe.

7. If tongs are used to apply torque, check that snub or dead lines and jerk lines are in good condition; snub or dead lines should be double cables.

**NB: NEVER REMOVE SNUB OR DEAD LINES**

8. Tighten tool joints (especially for tubing), giving 30% more right hand torque than in the left hand torque calculated at step 5 (if not done previously).

**Method for applying torque with slips:**

(a) Make pull equal to value found in Step 5.

(b) Set pipe in slips.

(c) Tie slip handles with soft line.

(d) Apply required right hand torque.

(e) Let torque come out, counting number of turns.

(f) Repeat, applying torque until all torque which has been put in comes out again.

*Note:* This method in practice does not allow the right hand torque to be transferred to the stuck-point; consultation with Sydney Office is advised if the correct procedure for transferral unfamiliar.

9. Lock hook and elevators on travelling block.

10. Ascertaın that mud level in pipe is not considerably lower than level in annulus.

11. Select proper sling for attaching upper sheave (equal to twice the breaking strength of the cable). Hoist upper sheave in derrick and attach with sling to derrick structure. Do not hand sheave on travelling block or on sandline.

**8.1.7 Preparation of the String**

(To be done immediately before running back-off shot in the hole).

1. Pull on pipe with value calculated in point 5.

2. Set pipe in slips. Lower travelling block until elevators are well clear of tooljoint (leave elevators closed around drillpipe).

3. Tie slip handles together with piece of soft line.

4. Apply left hand torque: number of turns as calculated in point 5.

5. Release torque slowly and count how many turns come out.
6. If fewer turns come out than have been put in, repeat steps 4 and 5 until number of turns coming out = number of turns put in.

7. Re-apply left hand torque as in Step 4 and hold with rotary lock (or tongs).

8.1.8 Back-off Operation

1. Position back-off shot opposite collar by using CCL.

2. Check that derrick-floor is cleared of all personnel.

3. Fire back-off shot.

4. After detonation of the string shot, the connection is often found to have spun completely free. In some cases, however, the connection may only have partially back-off. To complete the back-off:

   (a) Apply up to half the original left hand torque used, noting the ammeter or rotary torque gauge for indications of back-off. If back-off is indicated, continue until complete.

   (b) If the torque is not lost, it is usually an indication that the hook load is incorrect. Correct this by applying half the original left hand torque with the rotary and holding it with the rig tongs. Pull the slips and adjust the hook load. When the load is correct, the torque will be released.

5. Pull up pipe a few feet to confirm that the pipe is free. Make certain that no residual torque remains when pipe is picked up. The CCL may be used to check that the string has backed-off at the desired point.

   If the back-off is not successful, the string shot may be increased by 2-3 strands of primer cord over the Schlumberger recommended charge for a second attempt.

8.2 Lost Circulation

8.2.1 General

Lost circulation or lost returns may be defined as the loss of whole mud to the formation. The loss may vary from seepage of a few bbls/hour to complete loss of returns. Lost circulation occurs when the pressure of the mud column exceeds the formation pressure. A properly planned casing program and good drilling practices can reduce the occurrence of lost circulation.

   (a) Unconsolidated, Coarsely Permeable Formations

Unconsolidated formations of sand or pea gravel are usually found close to the surface, but may be found at any depth. Normally these are drilled (sometimes without returns) and cased off without difficulty. Controlled drilling rates may minimise this type of loss in larger holes.

   (b) Cavernous and Vugular Formations

Cavernous or honeycombed zones are normally found in limestone and dolomite formations. This type of loss is usually predictable in a given area because it occurs in definite formations which are easily traceable. In
this type of loss, abnormally rough drilling may precede the loss, and the bit may drop from a few inches to several feet. Returns will usually cease suddenly and completely. This type of loss is the most difficult to cure. Blind drilling usually is the most feasible solution if it can be done safely, although foam and air drilling have been applied.

(c) Fissures and/or Fractures

Any type of rock may have natural fractures. Fractures may be the result of jointing, fissuring or faulting. Loss in this type formation requires a bridging agent to seal the fractures.

(d) Mechanically Induced Fractures

A formation (normally a shale zone) which did not have a loss of circulation when penetrated may have fractures induced during drilling operations. Excess pressure may break down these weakened zones already drilled and cause loss of circulation. Excess pressures can result from solids build-up from fast penetration rates, turbulent annular velocities, spudding the bit while circulating, pressuring up on a mud ring, and fast tripping. The loss is usually sudden and complete. Induced fractures should be suspected if the same interval has been drilled in offset wells without loss.

8.2.2 Procedure for Lost Circulation Prevention

1. Keep mud density to the minimum required to control pressure plus provide some safety margin. Pressure which will cause lost circulation (fracture pressure) at the shoe is determined through leak off tests.

2. In areas of known lost circulation, keep gel strengths and viscosity to a minimum.

3. Break circulation slowly. To minimise pressure surges, start pump while picking up pipe and rotating. N.B. especially after trip.

4. Use reduced pump pressure when drilling through known lost circulation zones in order to reduce bit pressure drop or utilise larger nozzles to reduce bit pressure drop.

5. Time drill known lost circulation zones to prevent loading the annulus with excess cuttings.

6. Avoid excess trips through lost circulation zones.

7. Avoid fast tripping.

8. Avoid pre-treating with lost circulation materials when possible. An LCM pill is often all that is required, and if properly spotted, will be just as effective as treating the whole system, while having the added advantage of keeping mechanical solids control equipment operable.

9. Drill with no returns through lost circulation zone when possible before treating for lost circulation, as the high cost of lost circulation treatments, coupled with bridging characteristics of materials and heating characteristics of formations make consolidation of all losses economically and operationally desirable. Drilling "blind" should only be carried out with approval of Drilling Manager.
8.2.3 Lost Circulation Whilst Drilling

The following procedure should be followed when surface losses become apparent:

(a) Check all surface equipment for open valves (HCR) on flare line etc.

(b) Slow pump rate to see if circulation returns.

(c) Determine actual losses at specific pump rates.

(d) Reduce mud weights if possible.

Notes

1. Minimise pressure surges by careful down-hole drill string handling. This can often reduce lost circulation problems.

2. Leave out stabilisers, in order to avoid swabbing out LCM pills when moving the pipe, if it is anticipated that these pills will have to be spotted.

3. It is usual practice to leave the jets out of bits if LCM spotting is anticipated.

8.2.4 Locating Loss Zones

Successful treatment of lost circulation depends upon accurately locating the interval in which fluids are lost. Unless caverns are encountered, most losses will be found above the bottom of the hole and may, in fact, be at or just below the bottom of the last casing shoe. Loss of time and materials will result if the loss zone is not located, especially if any type of plugs are to be set. Various methods are available, eg temperature surveys, and will be advised from main office.
8.2.5 Lost Circulation Materials

Two types of plugging materials are available:

(a) Non-acid soluble plugging materials:

- e.g. Mica, Mudfibre, Cellophane, Walnut shells, Peat.
  These materials are suitable for combating mud losses in a non-productive formation. Many of these are available in various grinds for the differing applications.

(b) Acid soluble plugging materials:

- e.g. Calcium carbonate.
  Above materials are usually applied to cure losses in productive zones, but should be treated with care.

8.2.6 Types of Losses and Procedure for Treatment

1. Light (Seepage) Losses

This is usually 0.5 to 3 barrels per hour loss indicated when flow does not return immediately after connections. The first step to cure would be to pull up and wait or to drill ahead with partial returns if the next casing point is coming up. Attempts to cure with flakes of cellophane or mica can help. "Kwikseal" or a similar product at 10-30 lb/bbl is effective. Any good water loss control agent will help as an effective filter cake should be built quite quickly.

2. Moderate Losses

These are indicated by drop in pit level. Mica fine (20 lb/bbl) with a nutplug medium to coarse (10-20 lb/bbl) to begin building the bridging material is effective. Squeezing by applying backpressure is effective and usually a good filter cake building mud will remedy the situation. The concentrations of the various products used is usually determined on site by factors such as pumpability and screen blinding.

3. Complete Losses

This is indicated by total loss of flow in flowline and immediate drop in pit level. Pump pressure will usually drop also. Many methods are available to overcome the problem. If LCM additions cannot control the losses, then more drastic procedures are required.

(a) "Flochek" Procedure

1. General

Halliburton's product, "Flochek", has been used successfully in Australian land operations.

Rig up cement pump truck and rig pumps to the floor using a "tee" manifold. The success of the operation depends on being able to alternate easily and quickly between rig and cement truck. The pump truck should be tied in to two storage tanks of at least 50 bbls each, and a fresh water supply to the unit supplied. A cutting
blade is required to mix chemicals into the storage tanks.

The following is a typical "treatment" and may have to be repeated several times.

2. **Solution Preparation** - note: adequate fluid is prepared to allow for tank residual.

   SOLUTION A: Calcium Chloride solution - Mix 1750 lbs CaCl₂ in 50 bbls of fresh water giving a 10% solution. Use rig mud tanks.


   SOLUTION C: Cement Mixwater. Using the other storage tank completely dissolve 78 lbs of THIXSET A in 25 bbls fresh water followed by 40 lbs THIXSET B. Thoroughly mix and recirculate tank to ensure complete dissolution.

3. **Procedure**

   • R.I.H. open ended drill pipe to suspected lost circulation zone: keep accurate check of pipe in hole.

   • Pump 20 bbls of Solution A;
     Pump 10 bbls of fresh water;
     Pump 20 bbls of Solution B;
     Pump 10 bbls of fresh water;
     Pump 20 bbls of Solution A;
     Pump 10 bbls of fresh water;
     Pump 20 bbls of Solution B;
     Pump 10 bbls of fresh water.

   Mix and pump 30 bbls of cement slurry
   - 130 Sx (94 lbs) neat Class A + 19.5 bbls SOLUTION C.

   Slurry Wt 14.8 ppg
   Yield 1.32 ft³/sk
   Water Requirement 6.3 gal/sk

   Displace cement to give balanced cement plug.

   Pull back to top of cement and circulate with mud.

   • Backpressure (up to 20 psi) can be applied at any time returns are seen provided solution A is past the bottom of the drill pipe.
Diesel Oil - Bentonite - Cement Squeeze

DOBC squeezes can be applied to lost circulation problems that cannot be remedied with any of the above. A DOBC slurry is prepared simply by mixing with a jet mixer, approximately 20 sx of cement and 20 sx of gel per 10 bbls of diesel oil. Each 10 bbls of diesel oil prepares 14 bbls of slurry.

Note: All pumping and mixing equipment through which the slurry will pass must be free of water. When displacing the slurry down the drill pipe, the slurry should be immediately preceded by 10 bbls of alcohol followed by 20 bbls of diesel oil and the slurry followed by 10 bbls of alcohol, then 10 bbls of diesel oil. Any slurry left in the bottom of the suction tank should be dumped. If the slurry is allowed to contact water, the bentonite and cement will hydrate and cause the slurry to begin to set.

DOBC squeezes have a number of significant advantages over neat cement squeezes. Rather than setting to a rigid mass, a DOBC slurry forms a tough, plastic-like plug which can deform as drilling proceeds. This reduces the likelihood of losing circulation from a non-rigid thief zone. With a DOBC squeeze, there is not the danger of the squeeze job failing to seal the lost zone because of mud contamination, although contamination should be avoided.

PROCEDURE FOR PLUGGING LOST CIRCULATION ZONES WITH DIESEL OIL BENTONITE CEMENT SLURRY

(a) If possible, drill without returns through all the lost circulation zone.

(b) If (a) not possible, pull out of hole. Go in hole with open-end drill pipe.

(c) Set bottom of open-end drill pipe approximately 30 to 50 ft above lost circulation zone and rig up pump truck.

(d) Determine volume required and mix slurry as per above ratios.

(e) Pump in 10 bbls alcohol, then 20 bbls diesel oil ahead of the slurry.

(f) Displace slurry down the drill pipe and follow with 10 bbls of alcohol, then 10 bbls diesel oil.

(g) When the 20 bbls cushion of diesel oil reaches the bottom of the open-end drill pipe, close rams and start pumping mud into the annulus with rig pump while the slurry is being pumped down the drill pipe. Pumping rates should be controlled so that the ratio of slurry volume to mud is 2 to 1.

(h) Displace one-half the slurry into the formation at a fast pumping rate. The drill pipe may occasionally be reciprocated slowly to watch for any indication that the slurry might be moving up the annulus. If the weight
indicator shows any increased drag, break the connections and raise the pipe until it is free. Make connection and continue displacement. Since the slurry has no pumping time limitations inside the pipe, there need be no concern over short shut-down period.

(i) Displace the next quarter of Volume of slurry (and mud) at one-half the rate used in Step (g).

(j) Displace the remaining quarter volume of slurry at a rate of one-half of the rate used in Step (i). Attempt hesitation squeeze in order to obtain a pressure build-up. Approximately 1 bbl of slurry should be left in the drill pipe at the completion of the squeeze. Do not attempt to reverse circulate, because mud will contact the slurry and “gel up” inside the drill pipe.

(k) POH and wait on gelation of minimum of eight hours before drilling out.

(c) **Barite Plug - Pressure**

In normal pressure control, a very critical situation can arise when a well begins kicking and losing circulation at the same time. Increasing the mud density to control the high pressure zone will only complicate the problem of lost circulation. When the abnormally-pressured zone lies below the thief zone, barite-plugging can be used to control the well.

An extremely heavy, high water-loss slurry is required for this technique. Barite-settling and deposition will form a solid plug in the open hole, weighing down and sealing off the high pressure zone. In addition, the high filter loss results in rapid dehydration, bridging the hole and further aiding in sealing off the pressured zone. Once a barite plug is in place, normal steps for regaining circulation may be taken with relative safety. Barite plugs weighting from 18-24 ppg may be prepared using barite, fresh water, phosphate (SAPP) and caustic soda. No viscosifiers are used and care must be taken to prevent contamination of the slurry with mud because rapid settling of the barite, once it is spotted, is a necessity. The plug should be rapidly pumped, set as close to bottom as possible, and then the drill pipe withdrawn to avoid sticking. Coarse grind barites are not recommended because they will not stay suspended long enough to spot. Brackish or salt water should not be used because the settling rate is drastically reduced.
A cementing truck should be used to mix the slurry. Barite is mixed with fresh water containing 1 lb/bbl phosphate (SAPP) and 0.2 lb/bbl caustic soda. The lines from the cementing truck can be connected directly to the drill pipe through a plug valve. To minimise the possibility of stuck pipe, the derrickman should be in the derrick and the elevators ready to come out of the hole immediately after pumping is completed.

**Procedure for Setting Plug:**

1. Determine how many feet of plug in the open hole is desired. 120-150 m (400-500 ft) is usually adequate.

2. Choose a slurry density (higher density weights are preferable).

3. Calculate bbls of slurry required and add 20 bbls.

4. Calculate amounts of barite, phosphate, caustic soda and fresh water needed.

5. Batch mix the slurry to an even consistency and pump it down the drill pipe. (Spot close to bottom and be ready to come out quickly).

6. Underdisplace by 5 bbls with mud.

7. Immediately pull up above the plug. Circulate until gas dissipates. Proceed with normal operations.

**The Following Seven Points are Important**

1. Too heavy a slurry will prevent bridging from occurring.

2. A minimum of 6 bpm rate down the drill pipe must be maintained during mixing or displacement or the barite will settle out in the drill pipe and can plug the bit.

3. The SAPP/water ratio is critical to obtain the best fluid loss for bridging.

4. You must use fresh water and the system should have a pH of 9.

5. A back pressure should be maintained during placement and stripping up out of the plug or more gas can enter the well bore and destroy the effectiveness of the plug.

6. Bulk barite is preferred so that 40 or more sacks can be mixed per minute.
7. A barite plug should not be followed immediately with cement. Firstly, see if it is effective and then run the cement.

Note: Constant consultation with Sydney Office would be required in this operation.

8.3 Fishing

8.3.1 General Practices

The standard fishing assembly is as follows:

OVERSHOT-JARS-Dcs-ACCELERATOR(?)-HWDP-DP-KELLY

The amount of D.C. run depends on what is left in the hole and what is available on the rig. To get maximum effect from jarring, however, the same amount of D.C. as left in the hole should be run on top of the jars.

If insufficient drillcollars are available, an Accelerator can be run on top of the drillcollars. The number of drill collars can then be substantially reduced - check with Sydney Office.

Do not run a safety joint. Experience has proven that jarring on a safety joint freezes this tool, and makes the tool useless. Also, it would not be possible to use a stringshot as no left-hand torque could be applied to the string.

The one exception to this rule is when a washover string is run. A full opening safety joint (drive joint made for jarring) is run below the standard fishing assembly so that internal cutters may be run when the washover string sticks and has to be backed off; on top of the W.O.S., a junk sub can be installed. When using a washover string, always use 5 - 10% diesel oil in the mud to reduce friction. When a twist-off occurs and penetration rates are high, circulate the hole clean first before pulling out of the hole.

Prior to connecting to the fish, circulate as required.

Always use a spiral grapple in preference to a basket grapple, whenever possible.

Do not use an overshot with oversize guide when a bent single is used.

If the overshot has engaged the fish and the backlash is out of the string, lower part of the string weight onto the overshot (+40% of fish string weight). Then pick up fish 1.5 - 2.5 m (5-8 ft) and drop string 0.6 - 1.2 m (2-4 ft) and catch it in the brake to make sure of a firm grip. Then POH. If an overshot is run after the fish has been milled over, always run an extension to avoid catching the fish on the milled part.

When fishing in an oversize hole, use a bent single (1 straight single below bent single if required) to facilitate screwing back on.
8.3.2 Jarring

Heavy pulling and jarring must be done with the kelly added to the string. On those rare occasions where this is not possible, the elevator latch should be secured by means of a rope or a chain, provided the tool joint above the elevator has a square shoulder. Never use an elevator for jarring if the tool joints have an $18^\circ$ shoulder taper.

Remove the kelly spinner (if externally mounted) if possible, before any jarring with the kelly is done to avoid damage and parts coming loose.

When sustained jarring is carried out, drilling line must be slipped at regular intervals to avoid permanent damage to the wireline at the crossover points. The time interval between slipping depends on the intensity of the jarring.

Regularly check the derrick and lifting equipment for loose bolts, etc.

Prior to jarring, always mark the string position at the rotary table.

The proper jarring method is to allow the jar to trip first with the required overpull before further overpull is applied.

**NOTE:** The use of 2 jars in tandem gives an additional insurance and increases the frequency of strokes which can be given in a certain time. Never, however, trip the upper jar until it is certain that the lower jar has tripped first. (Bleed some oil from the lower jar at surface to let it trip first.) If in doubt, do not trip any of the jars, but re-set them first.

8.3.3 Use of Junk, Reverse Circulating Junk Baskets

When using junk baskets, it is important to core approximately 15 cms (6") and then pick up the string to allow junk on the side of the basket to fall into the pilot hole, so that it can be recovered when coring is continued. Maximum length of core depends on the size of the basket, but is usually 0.4 - 0.6 m (1½ to 2 ft). Run a stabiliser on top of the basket to aid in dislodging junk stuck in the wall (undersized baskets only).

Use 3-6,000 lbs WOB, 45 RPM and circulate at 250-300 GPM.

If a basket is run, make sure that, after it is made up, the catcher fingers can rotate freely. Also check that the correct size basket is used for the junk in the hole.

8.3.4 Spears

The standard assembly for a spear is as follows:

Spear - Spearstop - Fishing jar (18" stroke) - hydraulic jar - DC - DP - Kelly.

The spear must be equipped with a pack-off rubber when circulation is required. Also a stop-ring or spear stop should be used (spaced as required), which will prevent stabbing too deep and will also make the release easier and prevents re-engaging deeper down. It is also needed to reset the jars. The distance from the stop ring to both 7" and 9¾" spears is 1.2 - 1.8 m (4-6 ft).

When engaging the spear, always make sure that a tooljoint is at a workable distance above the rotary table. This may require using pup joints.
If the spear has to be released and knocking down on the spear does not free it, then install the surface jar (4 ft stroke) below the kelly and jar down on the spear.

When a tap is used, DO run a safety joint, but leave out the jar.

**NOTE:** Check the spear stop OD when it is run in open hole, and use the stops only if hole conditions permit. Avoid using a full-circle spear. If done anyway, don’t use a spear stop.

### 8.3.5 Lost S.W.S. Bullets

If bullets are lost in the hole, run in with a rockbit and junk sub, rotate and circulate along the places where the bullets were lost to attempt to dislodge the bullets from the wall of the hole.

When on bottom, drill a few feet. If no significant torque is encountered, continue as per program.

If drilling indicates that there is junk on bottom, pull out and run a basket to fish for junk.

When it is reported that bullets are lost in the hole after a Schlumberger run and more runs have still to be made, Schlumberger can do so, provided the guns are not lowered below the spots where bullets were lost.

### 8.3.6 Fishing Tools - Standard Wellsite Inventory

The following tools should be on site as a minimum.

- Overshots and oversized guides with grapples, baskets and extension subs to catch all sizes of tools in hole.
- Hydraulic jars to match the D.C. string in use.
- Reverse or straight circulating baskets for hole size required.
- Junk subs for required hole sizes.
- Fishing tools to catch any contractors’ tools.

Optional are safety joints, tapertaps, accelerators to match jars, bumper and surface jars, casing spears with stop-rings and pack off assemblies.

Have a junk mill on site to match production hole size.
8.3.7 Effective Pull on Stuck Drill Pipe

When determining the pull on Stuck Drill Pipe, the actual weight of the string in air is to be used and not the indicated weight as recorded by the weight indicator.

Example

Depth - 9765'

Weight of Drill Collars in air
= 743’ of 6½” O.D. x 3” I.D. Drill Collars = 743 x 89 lb/ft = 66,100 lb

Weight Drill Pipe in Air = 9022’ x 19.5 lb/ft = 175,900 lb

Total weight of string in air = 242,000 lb

Indicator reading = 205,000 lb

Weight of hook, blocks, swivel, etc. = 27,000 lb

Pull reported at 100,000 lb over indicator reading = 305,000 lb

Less hook, block, swivel, etc. = 27,000 lb

Effective pull on string = 278,000 lb

Assuming that pipe is stuck on bottom, then the effective pull at the stuck point
= 278,000 - 242,000 (no buoyancy of pipe) = 36,000 lb

In order to apply a pull of 100,000 lbs at the bit, the Indicator Reading would have to be
= 242,000 + 27,000 + 100,000 = 369,000 lb

This would mean that the pull on the pipe amounts to
= 369,000 - 27,000 = 342,000 lb

Routine field practice is pull stuck pipe to 85% of the minimum yield strength unless differently advised by Sydney Office.
8.4 Drilling Coal

When drilling COAL, the Drilling Supervisor should ensure that the following procedures are followed:

1. Never attempt to drill more than five (5) ft of Coal without circulating. The circulating period does not have to be an extended one, 2 to 3 minutes is adequate. It is merely to give your drilling fluid a chance to move the mass of cuttings up hole. After circulating, slowly pull up above the Coal seam and attempt to run slowly back to bottom. If there is no fill on bottom, drill ahead another five feet, repeating the procedure and being sure to pull up above the first seam penetrated.

2. When working Coal seams, it is essential that the bit is pulled up so slowly that no swab pressure is exerted on the formation and reamed back to bottom in the same manner so that no surge pressures are created in the well bore. Both surge and swab pressures will cause pressure sensitive seams to slough or, in severe cases, literally explode into the well bore, increasing the problem dramatically.

3. If the Coal seams are stable and it is possible to drill ahead, maintain a close watch on the shale shaker. If the majority of your cuttings are Coal and your penetration rate indicates a formation other than Coal, then a Coal seam has sloughed up hole. Sydney Office should then be notified.

4. Under no circumstances, attempt to pull up through or jar through a Coal seam. The time lost circulating is very inexpensive compared to a fishing job.

5. Back reaming up through a Coal seam should also be viewed as a high risk operation, with the potential of an expensive fishing job being weighted against the cost of circulating for a few hours.

6. Slow trip times while running drill collars and BHA past Coal seams is essential to the stability of the seams.
SECTION 9.

PLUG AND ABANDONMENT PROCEDURES

Unless otherwise approved, the following guidelines for plugging and abandoning an onshore well should be adhered to:

9.1 Isolation of Zones in Uncased Portions of Hole

1. Cement plugs should be spaced to extend 50 m (160 ft) below the bottom to 50 m (160 ft) above to top of oil, gas and fresh water zones so as to isolate them in the strata in which they are found and to prevent them from escaping into other strata.

2. Cement plugs should be spaced to extend 90 m (300 ft) below the bottom to 90 m (300 ft) above to top of any workable mineral deposits encountered.

9.2 Isolation of Open Hole

Where there is open hole below the casing, a cement plug should be placed in the deepest casing string in accordance with paragraphs (a) or (b) below or in the event lost circulation conditions exist or are anticipated the plug may be placed in accordance with paragraph (c) below:

(a) A cement plug placed by displacement method so as to extend a minimum of 30 m (100 ft) above and 30 m (100 ft) below the casing shoe.

(b) A cement retainer with effective back pressure control set no less than 15 m (50 ft) nor more than 30 m (100 ft), above the casing shoe with a cement plug calculated to extend at least 30 m (100 ft) below the casing shoe and 15 m (50 ft) above the retainer.

(c) A permanent type bridge plug set within 45 m (150 ft) above the casing shoe with 15 m (50 ft) of cement on top of the bridge plug. This plug shall be tested in accordance with Section 9.8, prior to placing subsequent plugs.

9.3 Plugging of Perforated Intervals

A cement plug should be placed opposite all open perforations (perforations not squeezed with cement) extending a minimum of 30 m (100 ft) above and 30 m (100 ft) below the perforated interval or down to a casing plug whichever is less. In lieu of the cement plug, a bridge plug set at a maximum of 45 m (150 ft) above the open perforations with 15 m (50 ft) of cement on top may be used provided the perforations are isolated from the open hole below. Where a succession of bridge plugs is used to isolate succeeding perforated test intervals, the 15 m (50 ft) of cement should be placed on the top-most bridge plug and all should be tested to a minimum pump pressure of 1,000 psi.

9.4 Plugging of Casing Stubs and Liners

If a liner has been run and not tied back to the surface or if casing is cut and recovered, a cement plug 60 m (200 ft) in length should be placed to extend 30 m (100 ft) above and 30 m (100 ft) below the liner hanger or the cut end of the casing. A retainer may be used in setting the required plug.
9.5 Abandonment of Tubing

All tubing is to be pulled prior to the abandonment of a well.

9.6 Plugging of Annular Space

No annular space that extends to the surface should be left open to drilled hole below. If this condition exists, the annulus and the inner casing should be plugged so as to provide a column of cement extending 45 m (150 ft) above the depth of the outer casing shoe.

9.7 Surface Plug

Regulations vary from State to State and liaison with Sydney office is required.

9.8 Testing Plugs

Regulations vary from State to State and liaison with Sydney office is required. Usually tested and verified with 15,000 lbs weight.

9.9 Mud

Each of the respective intervals of the hole or casing between the various plugs should be filled with non-corrosive mud fluid of sufficient density to exert hydrostatic pressure exceeding the greatest formation pressure encountered while drilling such interval by at least 200 psi. Anti-bacterial additives should be added to this fluid.

9.10 Removal of Casinghead

(a) In certain circumstances casinghead sections will be required to be left on an abandoned well from which hydrocarbons have been produced.

(b) Where casingheads are left on an abandoned well, the requirement to place the surface plug specific in Section 9.7 above, may be waived.

9.11 Steel Cover Plates

A steel cover plate having an observation valve fitted into it should be installed on the abandoned wellhead.

(a) Where a casinghead is left, the cover plate shall be a mating, or companion flange, or a plate of similar or suitable specifications, with appropriate seal or sealing groove and ring gasket and shall be installed on the uppermost casinghead flange or connection, and may be required on casinghead side outlets whether or not side outlet valves are removed. Spot welding should be applied to all securing nuts and bolts.

(b) Where the casinghead is removed, the cover plate should be fully peripherally welded to the stub of the outermost casing.

9.12 Steel Well Markers

(a) A steel well marker plate should be installed 2 m (6.56 ft) above ground level, welded to a suitable steel post which is also welded to the side of the casinghead or outermost casing stub.
(b) The marker plate should have bead-welded onto it the well name, total depth, date spudded and date abandoned.

9.13 Re-establishment of Surrounding Area

Insofar as is possible or necessary, the well site area shall be restored to its former condition and if any part of a well-head is left above ground level, it shall be adequately fenced.

9.14 Water Wells

Details and status of any water well(s) drilled specifically for the operation shall also be included in the Abandonment Program. Should the licensee wish to either:

(a) convert an abandoned well to a water well;
(b) produce water from the casing annulus of an abandoned, suspended or producing well;

this must be subject to the submission of a new application.

9.15 Standard Practices

(a) Always use the “balanced plug” method of displacement in setting cement plugs.
(b) It is more desirable to under rather than over displace.
(c) Use caliper log to calculated required cement volume.
(d) Plugs are to be set with open ended drill pipe only, preferably with a “bull nose” attached.
(e) Once displacement is finished, pull pipe back to top of plug and circulate.
SECTION 10.

10 SAFETY AND ENVIRONMENT

10.1 General Safety

Safety is to be stressed throughout the drilling operation to all personnel on location.

A pre-spud Safety Meeting will be held by the Drilling Supervisor and logged in the tour sheet. All safety procedures and responsibilities will be reviewed at the time. Explanations of BOP stacks, arrangements and functions as well as peripheral well control equipment will be part of the safety demonstrations. In addition, weekly safety meetings will be held and a safety record maintained.

Explanation of reasons for blow-outs and related incidences shall be discussed. A complete physical check will be made of the rig to ensure equipment is in a safe operable condition.

Overall responsibility for drilling operations, procedures, instructions and safety requirements will be delegated by the Drilling Supervisor and the Toolpusher.

Operations will be carried out as per the relevant Drilling Program and any deviations from it due to safety considerations will be considered obligatory.

Procedures and practices will always come under the label "good oilfield practice".

10.2 Air Drilling Safety Checklist

1. All engines on location should be equipped with explosion resistant ignition.

2. All rig lighting should be vapour and explosion proof. Well heads, blowout preventers and the cellar should be illuminated with flood lights located as far away as possible for proper illumination.

3. The rig pumps should be connected to the stand pipe and well head at all times with the pits or tanks filled with appropriate mud or water sufficient to fill the well bore and ready for immediate use.

4. All chain guards should be solidly built and oil bathed where possible.

5. Use only spark resistant tools and spinning rope (not chain) when gas is used or may be encountered. Keep tool joints and the kelly drive bushing well doped. Keep all clutches properly adjusted to eliminate sparks.

6. The substructure should not be enclosed and adequate ventilation should be maintained to insure no accumulation of gas.

7. A sufficient amount of fire protection equipment should be on hand.

8. Signs should be posted at each approach to the location 60 meters from the rig warning that air or gas drilling is in progress. Visitors should be discouraged. Instruct all personnel of the fire rules.

9. No open fires should be allowed at the location. Pilot lights should be extinguished and stoves disconnected except for approved safety stoves.

10. A small house can be placed at a safe distance from the rig where personnel must
leave matches, cigarettes, etc. The driller should make an inspection of this men
at the beginning of each tour for compliance with this rule. Visitors should be
informed of the rules concerning fire safety.

11. **Automotive equipment** should be parked at a designated safe distance from the
rig.

12. Radios and mobile telephones should be located 60 meters from the rig.

13. The BOP’s should be checked for condition and operated or tested at a proper
interval and checked for proper pressure rating, height and bore. No rusted,
pitted, dented or bent ring gaskets should be used.

14. All valves on the choke manifold should be full opening, steel flanged valves and
checked before installation for working condition and check periodically.

15. The choke manifold should be so constructed that the chokes can be changed
without shutting in the flow.

16. The hydraulic BOP’s should be equipped with two control stations, one near the
driller’s position and the other at a safe distance from the well with all lines and
connections made of high pressure steel or approved piping.

17. The master valve feature of the annular BOP is for emergency use, to insure safe
operation. It is not to be closed on open hole more than necessary.

18. Check all BOP’s and lines with fluid pressure before drilling and correct any leaks.

19. Check operation of BOP’s each trip.

20. Use floats in drilling string and check each trip.

21. In case of high pressure fluid or gas entry, do not close BOP’s until chokes are
open and do not close the well in tight until it has been filled with liquid.

22. Gas/Air supply line should be equipped with a high pressure shut-off valve located
30 metres from the well.

23. The air compressors should be inspected and equipped with all normal safety
features.

24. The “bloopie” line should be of adequate O.D. to insure discharge of cuttings and
anchored for safety, extending at least 45 meters from well, placed at right angles
to the prevailing downwind side of the location if possible and equipped with a pilot
light that should be lighted while drilling and extinguished before the rotating
assembly is removed.

25. An education program, safety routine and inspection check list should be
established to acquaint all personnel with air and/or gas drilling.

26. Crew members should have full knowledge and instruction in the use of BOP’s,
choke controls, etc.

27. When toxic materials are used, authorised personnel **only** should handle the
material.
10.3 **Housekeeping**

Good housekeeping is a must in any drilling operation. Particular emphasis should be placed on the area around the rig floor. Paints and flammable materials will be isolated and stored in one remote place. Care should be exercised in storing mud, chemicals and cement. Caustic soda, calcium chloride and zinc chloride are particularly hazardous.

All tools and equipment not in immediate use shall be kept, picked up and sorted in their proper storage area.

Oil spills will be cleaned up immediately. Hydrocarbons and flammable fluids will be used for cleaning only at the discretion of the Toolpusher. Oily rags and other substances that present a fire hazard will be disposed of in such a manner so as not to violate pertinent pollution regulations.

First aid kits, fully equipped, will be available at all times and the material therein kept up to date at all times (see Appendix A).

10.4 **Fire Protection, Prevention and Equipment**

The following regulations and notes should be complied with:

1. Adequate fire fighting equipment, in accordance with Mines Department regulations, will be provided and shall be utilised only for fire prevention.

2. The Drilling Supervisor will inspect fire fighting equipment weekly. Such inspections will be recorded in the tour report and morning report.

3. All fire extinguishers will be checked every six months. All fire extinguishers will be immediately refilled after being used.

4. All fire hoses will be pressure tested to normal working pressure once each six months.

5. Any gas vented or flared from the well will be ignited a minimum distance of 45 m (150 ft) from the well-bore if possible.

6. All unnecessary electrical equipment will be secured during DST.

10.5 **Personnel Safety**

1. Safety hats and eye protection shall be worn in all relevant areas at all times.

2. All personnel engaged in operations on the Rig shall wear long pants and shirts and all other protective equipment (including 1. above) such as steel toe capped boots conforming to Australian Standards.

3. All machinery will be operated by Authorised Personnel only. The Toolpusher will ensure that this procedure is followed.

10.6 **Environment**

The on-site drilling supervisor is responsible for ensuring that chemical spills of any nature are sufficiently dealt with so that there will be no long term impact on the environment. In his absence, the contractor's representative has the authority to implement spill control procedures.
Any unauthorised discharge of waste oils on roads or adjacent ditches is an unacceptable disposal option. If such a spill should occur, the polluted area would be scraped and the contaminated earth would be transferred to a containment pit, or the sump, and buried under one metre of fill.

Sanitary wastes (camp wastes) are to be contained in a sump and disposed of on-site. Garbage and other related materials including combustible and non-combustible materials will be incinerated and the remaining debris will be buried under one metre of dirt.

The APEA "Code of Environmental Practice - Onshore and Offshore", February, 1988, is to be adhered to in the relevant situations. A copy of the code will be made available at each well-site location.

10.7 Reporting

Any relevant Accident Report Forms, Safety Check Sheets, etc., required by Government will be forwarded to the rig for completion by the Drilling Supervisor. The completed sheets will be returned to the Sydney Office and redirected to the relevant authorities.

A monthly accident statement will be provided by all the operators, all contractors and third parties. Such reports will be submitted to the Mines Department in respective State or Territory.
SECTION 11.

11 EMERGENCY RESPONSE PLANS

11.1 General Emergency Procedures

In order to effectively cope with situations on the well site where advice or action from Head Office is required Pacific and Ozoil will have a member or staff "on duty" at all times while drilling rigs are operating. Contact numbers for on duty staff are provided in the Well Proposal and shall be posted in the Site Office.

In the event the Drilling Supervisor decides that the situation warrants, he should contact Pacific who will liaise with the appropriate Government bodies, media, etc. Where specialist advice is required Pacific shall delegate responsibility for co-ordinating operations to Ozoil.

In the event of a medical emergency an Emergency Medical Assistance plan (EMA) has been prepared for each well location. Details of the EMA are included in Section 1.5 of the Well Proposal and are to be posted beside each telephone.

An Occupational Health and Safety Officer will be nominated at each safety meeting. The OH&S Officer will be responsible for administering first aid at the rig site and ensuring all emergency equipment and procedures are in place. The OH&S Officer will also ensure that all accidents are reported in accordance with Government regulations.

11.2 Drills

In order to familiarise everyone on the rig with those procedures, which require rapid co-ordinated action, drills are to be held regularly in which emergencies are simulated and the correct reactions are practised.

The drills are held for:

- Medical Emergency and Evacuation;
- Fire and Blowouts;
- \( \text{H}_2\text{S} \) (if deemed necessary).

11.3 Medical Emergencies

11.3.1 General

Accidents will undoubtedly occur and all attention is paid to keeping them to an absolute minimum.

Usually there will be no medical staff available at rig site and, should an accident occur, then judgement will be required as to whether an emergency should be called. If in any doubt whatsoever, the incident must be treated as serious.

11.3.2 First Aid Requirements

A complete Royal Flying Doctor Medical kit will be on site at all times under the direct control of the Toolpusher and/or Drilling Supervisor and in accordance with the relevant Mines Department regulations. A minimum list of requirements for a "first-aid" kit appears in Appendix A and "First Aid Procedures" are covered in Appendix B.
11.3.3 **Medical Services**

At the well site location, a qualified Medic will be available at all times to assist any injured person. First Aid treatment must continue after Rescue Operations have been initiated and continue until a Medical Doctor or Qualified Nurse/Ambulance Attendant takes over care of the patient. With the treatment of patients, it is important to note that death should never be presumed.

11.3.4 **Emergency Support**

If an injury has occurred and transportation is not available from the wells site, contact must be made with the R.F.D.S to make the necessary travel arrangements and to treat the patient under the direction of a qualified Medical Doctor.

An airstrip will be located as close as possible to wells site.

There will be two four-wheel drive vehicles available and it is the Drilling Supervisors’ responsibility to ensure that these are maintained in a condition for immediate use should any emergency arise; i.e. fully fuelled, water and oil checked, spare tyres and spare fan belts, etc.

Should an evacuation be necessary by vehicle, it is essential that two vehicles leave the site in case of breakdown.

There will be a telephone onsite to contact with emergency numbers and a back- facility of an H.F. Radio provided by the Drilling Contractor.

11.3.5 **Vehicular Travel between Wellsite and Town**

Under no circumstances, is any person to travel between Town and Wellsite without informing the Drilling Supervisor or Toolpusher and giving them an estimated time of arrival at their destination.

It is then the responsibility of the Drilling Supervisor and Toolpusher to ensure that the person has arrived at his destination. If not, then a search party will be sent out to look for the person.

This applies to Service Company personnel as well as it is the Drilling Supervisor’s responsibility to ensure that they are informed of this procedure.

11.4 **Blowout (and Fire) Emergencies**

11.4.1 **General**

Prior to the event, the exact requirements for the killing operation cannot be accurately defined. Much of the technical, logistical and planning work can only be initiated when a “blow-out” has occurred and the available data acquired, assembled and interpreted.

In all instances of a major catastrophe, the organisation and the communication and co-ordination between the supervisors is very important to the quick and efficient execution of remedial action.
11.4.2 Responsibilities

The various responsibilities for the planning and execution of the wild well control operation are as follows:

- **Drilling/Operations Manager (Ozoil)**
  
  Overall co-ordination of the planning well control operations.

- **Drilling Engineer**
  
  Responsible for all technical matters associated with the drilling and well control operations and for specifying additional equipment which is required.

Both are responsible for all matters relating to safety, pollution, fire-control and especially Medical Evacuation that would be required (see Section 11.2).

11.4.3 Communications

A fully-equipped control centre will be established either at rig-site or at a suitable location equipped with telephone and facsimile facilities. Extra staff will be added to man the centre 24 hours a day. Sydney Office will act as the main base and provide all the necessary communications to Government authorities, the Press and other relevant Joint Venturers.

11.4.4 Equipment

A decision on kill procedure would likely come very soon after blow-out and it is expected that an "in-situ" kill would follow. If relief wells were needed then it is anticipated that suitable drilling units needed would be available on location within days. Actual timing will be dependent upon the stages of wells in progress in which operations may have to be interrupted and the wells temporarily suspended, mobilisation of unoccupied rigs, weather conditions, etc.

11.4.5 Kill Programs

It is anticipated that it could take up to one week to finalise detailed well killing programs, including review, discussion and approval.

If further key expert personnel were required these would immediately be mobilised to location (maximum 5 days from the U.S.). If relief wells were to be drilled, then siting and building of leases would be undertaken.

If an "in-situ" kill operation were to be undertaken, then steps to clear the site ready for access would be implemented. At this stage, it is expected that the efflux would have been ignited and, if not, this would be done under the strictest of guidelines.

11.4.6 Conclusion

Although the dimension of the problem should not be underestimated, the acquisition of the majority of the equipment required could and would be obtained quickly from sources in Australia. Other equipment which may have to be acquired could be on-site in time for the kill operation.
11.5 **Hydrogen Sulphide (\(\text{H}_2\text{S}\)) Gas - Emergency Response**

Since hydrogen sulphide (\(\text{H}_2\text{S}\)) gas is so potentially dangerous, the detection of even low concentrations of the gas is cause for alarm. This is especially true in view of the fact that concentrations above 100 ppm impair one's sense of smell and render a person unconscious without him/her ever realising the presence of the gas.

Generally speaking, on a drilling location the source of \(\text{H}_2\text{S}\) gas is either from the drilling fluid (i.e. dissolved gas breakout in the shakers) or a kick (a gas bubble circulated to surface). Should the presence of \(\text{H}_2\text{S}\) gas be detected, the on-site drilling supervisor is to ensure that operations cease until the source of the gas have been identified and steps have been taken to rectify the problem.

In the event that there is an uncontrolled blow of \(\text{H}_2\text{S}\) gas, or, concentrations of \(\text{H}_2\text{S}\) gas on lease in excess of 100 ppm, the on-site drilling supervisor will institute emergency evacuation procedures.

**Note:** For details on the symptoms of \(\text{H}_2\text{S}\) gas poisoning, refer to the attached chart (Table 11.4).
# Toxicity of Hydrogen Sulphide to Men

<table>
<thead>
<tr>
<th>H₂S Percent (PPM)**</th>
<th>0 to 2 Minutes</th>
<th>2 to 15 Minutes</th>
<th>15 to 30 Minutes</th>
<th>30 Minutes to 1 Hour</th>
<th>1 to 4 Hours</th>
<th>4 to 8 Hours</th>
<th>8 to 48 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.005 (50)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.010 (100)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.015 (150)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.015 (150)</td>
<td>Coughing,</td>
<td></td>
<td>Disgust,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Irritation of eyes,</td>
<td>Loss of sense of smell</td>
<td>Pain in eyes,</td>
<td>Sleepiness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.020 (200)</td>
<td>Loss of sense of smell</td>
<td>Throat &amp; eye irritation</td>
<td>Throat &amp; eye irritation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.025 (250)</td>
<td>Irritation of eyes,</td>
<td>Loss of sense of smell</td>
<td>Irritation of eyes</td>
<td>Painful secretion of</td>
<td>Light shy,</td>
<td>Nasal catarrh,</td>
<td>Haemorrhage &amp; death*</td>
</tr>
<tr>
<td></td>
<td>Loss of sense of smell</td>
<td></td>
<td></td>
<td>tears,</td>
<td>Pain in eyes,</td>
<td>Difficult breathing</td>
<td></td>
</tr>
<tr>
<td>0.035 (350)</td>
<td>Irritation of eyes,</td>
<td>Loss of sense of smell</td>
<td>Difficult respiration,</td>
<td>Coughing,</td>
<td>Irritation of eyes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Loss of sense of smell</td>
<td></td>
<td></td>
<td>Irritation of eyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.045 (450)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.050 (500)</td>
<td>Coughing,</td>
<td>Respiratory disturbances,</td>
<td>Serious eye irritation,</td>
<td>Palpitation of heart,</td>
<td>Severe pain in eyes &amp; head,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse &amp; Unconsciousness</td>
<td>Irritation of eyes,</td>
<td>Few cases of death*</td>
<td></td>
<td>Dizziness,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.060 (600)</td>
<td>Collapse*</td>
<td>Unconsciousness,</td>
<td>Unconsciousness,</td>
<td>Death*</td>
<td>Unconsciousness,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death*</td>
<td></td>
<td></td>
<td>Death*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Data secured from experiments of dogs which have a susceptibility similar to men. ** PPM - parts per million.
11.5.1 Communications and Evacuation Procedure

At first indication of an emergency situation, the on-site drilling supervisor is responsible for coordinating the movement of personnel on location and in ensuring the safety of the same. In his absence, the drilling Contractors' representative will be in charge.

Recommended safety measures to follow in the event of an emergency situation involving hydrogen sulphide gas include:

1. **Assessment of the Situation**

   Initiation of notification procedures begins with an assessment of the situation, which includes:

   **A. Current Situation**
   - Area of gas flow, i.e. drill pipe or annulus.
   - Status of BOP equipment - i.e. good, failed, burned, etc.
   - Status of major rig equipment - i.e. pumps, motors, mud systems
   - Estimate of flow rate.
   - Whether on fire.
   - Define status of support equipment - i.e. power, lights, communication.

   **B. Potential Hazards**
   - Risk of fire.
   - Risk of explosion.
   - Chemicals in vicinity.

   **C. Weather Conditions**
   - Wind speed and direction.
   - Visibility.
   - Air temperature.
   - Rain.

2. Ensure BOPs are shut-in and kick procedures are followed.
3. Kill all motors with air shut off.
4. Shut off all electrical controls.
5. Account for all personnel on location by utilising the camp log and the services of the OH&S Officer.
6. Prepare to commence rescue and medical treatment as required, including notification of area hospital facilities.
7. Contact Katherine Hospital. During the initial stages of an emergency, no is allowed entrance to the well location unless special clearance is obtained from the on-site Drilling Supervisor.
8. Contact Head Office and the Ozoil Drilling Superintendent, for consultation.

11.5.2 Hydrogen Sulphide Ignition Guidelines

If an emergency situation exists such that there is an uncontrolled or potentially harmful release of H\textsubscript{2}S gas that may lead to loss of life, the decision to ignite will be made by the on-site drilling representative. Normally, this decision will be made after the Sydney Office has been contacted.

11.5.3 Ignition Procedure

1. Ensure that the immediate area is evacuated of all personnel.
2. Select two men to check all self-contained breathing apparatus.
3. Establish escape routes and have a back-up team with rescue equipment nearby and ready in case of trouble.
4. Ignite the gas release.

11.5.4 Sulphur Dioxide

After the ignition of an H\textsubscript{2}S gas release, the area must be monitored for sulphur dioxide concentrations (SO\textsubscript{2}), as SO\textsubscript{2} is a product of combustion. SO\textsubscript{2} emissions are easily detectable as the odours are extremely harsh and irritating with harshness increasing with concentrations.

Although SO\textsubscript{2} vapour is more toxic than H\textsubscript{2}S emissions, it is considered less dangerous due to the fact that, unlike H\textsubscript{2}S gas, its harsh odour and irritating nature make it readily detectable at less than harmful concentrations. In comparison to H\textsubscript{2}S gas:

- Less than 1 ppm can be harmful to plant life.
- 0.3 to 1 ppm can normally be detected by taste as well as smell.
- 6-12 ppm is immediately irritating to the nose and throat.
- 20 ppm is irritating to the eyes.
- 400-500 ppm can be lethal.

When SO\textsubscript{2} concentrations are 2.0 ppm for two to three hours or 0.3 ppm to 1.0 ppm for twenty-four hours or more, evacuation is recommended.

11.6 Emergency Contacts

Telephone contacts for all aspects of each well are given in the individual Well Proposals and should be checked by the Drilling Supervisor to ensure all information is available and accurate.

In the event of a medical emergency, telephone contacts for medical assistance are outlined in the Emergency Medical Assistance plan located in Section 1.5 of the Well Proposal and posted beside each telephone at the well site.
APPENDIX A

MINIMUM FIRST AID REQUIREMENTS
TO BE MAINTAINED ON LOCATION
The following list has been collated based on the minimum requirements as specified in the Code of Practice "First Aid in the Workplace" Occupational Health and Safety Act 1985 (Victoria). This list satisfies the Northern Territory Department of Mines and Energy "Schedule of Onshore Petroleum Exploration and Production Requirements 1993 (Draft) and the Work Health (Occupational Health and Safety) Regulations of the Northern Territory of Australia.

Three first aid kits will be on site at all times. The kits will be located in the first aid room, the dog Box and in the kitchen. Each kit will contain the following items as a minimum.

<table>
<thead>
<tr>
<th>Table</th>
<th>EACH KIT</th>
<th>TOTAL ON SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Aid Notes</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>(Australian First Aid, Vol. 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individually wrapped sterile adhesive dressing</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td>Sterile eye pads</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Sterile covering for serious wounds</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Triangular bandages</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Safety pins</td>
<td>12</td>
<td>36</td>
</tr>
<tr>
<td>Small sterile unmedicated wound dressing</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Medium sterile unmedicated wound dressing</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Large sterile unmedicated wound dressing</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Adhesive tape 1.25cm wide</td>
<td>1 roll</td>
<td>3 rolls</td>
</tr>
<tr>
<td>Rubber thread or crepe bandage</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Scissors</td>
<td>1 pair</td>
<td>3 pair</td>
</tr>
<tr>
<td>Disposable gloves</td>
<td>1 pair</td>
<td>3 pair</td>
</tr>
<tr>
<td>Eye Module - Guidance Notes</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Eyewash</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Sterile eye pads</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Adhesive tape 1.25cm wide</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Burns Module - Guidance Notes</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Assorted size burns dressing</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Clean sheeting</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

The above list for each kit is the minimum requirements for a Basic Occupational First Aid Kit with additional eye and burns modules (Occupational Health and Safety Act 1985, Victoria).

In addition, one instant ice pack should be included in the first aid kit in the dog box and kitchen, with three instant ice packs in the first aid room.
The following items will be housed in the first aid room; in addition to the minimum contents of the first aid kit listed previously.

- Oxygen breathing apparatus (including spare oxygen cylinders)
- Stretcher
- Splints
- Air splints (2 sets)
- Tube Antiseptic Cream
- Detergent Antiseptic
- Gauze Swabs
- Splinter Forceps
- Medicine Measure

All injuries must be reported to the Northern Territory Department of Mines and Energy. Refer to the "Schedule of Onshore Petroleum Exploration and Production Requirements 1993" Division 4.
APPENDIX B

FIRST AID PROCEDURES

(Refer to the authorised manuals of St John Ambulance Australia. Australian First Aid, Vol. 1)

Manuals will be kept in the first aid room and with the first aid kit on the rig and in the camp kitchen.
Recognised hazards and types of injuries that may occur at the wellsite.

- Bites (snake, spider, scorpion)
- Sunburn
- Overexposure to heat
- Thermal burns
- Chemical burns
- Chemical burns to the eye
- Eye injuries
- Welding flash
- Lacerations
- Abrasions
- Fractures
- Crush injuries
- Internal bleeding
- Shock
- Electrocution
- Sprains
- Strains
- Dislocations
- Spinal injuries
- Ear damage due to excessive noise levels
1. General First Aid

First aid is the immediate and temporary care given to a person who has been injured or suddenly taken ill. It includes self-help and adequate care if medical assistance is not readily available or is delayed. It also includes well-selected words of encouragement, evidence of willingness to help and promotion of confidence by demonstration of competence.

Immediate first aid care on the job is very important, not only in what to do, but what not to do. ALL ACCIDENTS SHOULD BE REPORTED TO THE DRILLER, TOOLTIPUSHER AND OH&S OFFICER IMMEDIATELY. Timely and proper care can mean the difference between life and death, between temporary and permanent disability, and between rapid recovery and long hospitalisation. Equipment should be fully maintained and if damaged be repaired as soon as possible.

This section is designed to provide broad guidance in first aid, particularly for the drilling industry and does not give a detailed first aid treatment for every case.

To assure prompt care and adequate handling of drilling injuries, the OH&S Officer should contact local medical facilities as soon as possible upon moving into a new drilling area in accordance with the EMA. He should confirm current information regarding names, locations and telephone numbers of the physicians, hospitals, helicopters or ambulance services. The EMA should be kept posted in the dog house, change rooms and beside each telephone.

2. First Aid Training

Because drilling operations are generally conducted at remote locations where medical aid is not readily available, it is mandatory that one crew member on each shift be qualified to administer first aid. It should be clearly understood that, all injuries no matter how minor should be reported to the OH&S Officer who will decide if further medical attention is warranted.

An adequate supply of uncontaminated water should be available for flushing all types of burns, including chemical reactions. Suitable commercial eye wash neutralisers should be located where quickly accessible to the employees. Common household vinegar will neutralise caustic soda reaction, however it is NOT to be used for burns to the eyes.

Each crew member should be instructed and adequately trained to rescue anyone who may have been overcome by toxic gas or other contaminated air. It is important to remember that he, himself, must be equipped with proper respiratory equipment and a lifeline before entering the hazardous area (see Section 11.4).

3. First Aid Kits and Supplies

This is covered in Appendix A and every effort should be made to keep the kit up-to-date and well stocked. All first aid kits should be checked by the OH&S Officer.

An adequate supply of medical oxygen to use with an automatic resuscitator, should be available for emergency use. Special training is required in the use and storage of the respirator on location. Continuous training should be conducted to operate the resuscitator by the use of drills or special exercises.

A complete set of inflatable air splints, or other suitable splints, should be made available at each work site.

An approved first aid manual should be a part of the first aid kit or supplies at each location.
APPENDIX 3

Recommended Bit and Hydraulics Programme
# RECOMMENDED BIT AND HYDRAULICS PROGRAMME

## WELL: BURDO-1

<table>
<thead>
<tr>
<th>BIT NUMBER</th>
<th>1&lt;sup&gt;1&lt;/sup&gt;</th>
<th>2&lt;sup&gt;2&lt;/sup&gt;</th>
<th>3&lt;sup&gt;3&lt;/sup&gt;</th>
<th>4&lt;sup&gt;4&lt;/sup&gt;</th>
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<td>6</td>
<td>6</td>
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<tr>
<td>Type</td>
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<td>4.37</td>
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<td>510</td>
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<tr>
<td>Out (m)</td>
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<td>330</td>
<td>510</td>
<td>519</td>
</tr>
<tr>
<td>Total (m)</td>
<td>60</td>
<td>270</td>
<td>180</td>
<td>9</td>
</tr>
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<td>R.O.P. (m/hour)</td>
<td>5.0</td>
<td>5.0</td>
<td>4.0</td>
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</tr>
<tr>
<td>Hours</td>
<td>12.0</td>
<td>54.0</td>
<td>45.0</td>
<td>4.5</td>
</tr>
<tr>
<td>W.O.B. (1,000 lbs)</td>
<td>2 - 10</td>
<td>10 - 25</td>
<td>10 - 20</td>
<td>5 - 15</td>
</tr>
<tr>
<td>R.P.M.</td>
<td>150</td>
<td>120 - 150</td>
<td>70 - 90</td>
<td>60 - 150</td>
</tr>
<tr>
<td>B.H.A.</td>
<td>4 x 6½&quot; 2 x 8&quot;</td>
<td>3 x 4½&quot;</td>
<td>3 x 4½&quot;</td>
<td>3 x 4½&quot;</td>
</tr>
<tr>
<td></td>
<td>JARS</td>
<td>JARS</td>
<td>JARS</td>
<td>JARS</td>
</tr>
<tr>
<td></td>
<td>3 x 4½&quot;</td>
<td>14 x 4½&quot;</td>
<td></td>
<td></td>
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<td></td>
<td>10 x 6½&quot;</td>
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<td>STAB</td>
<td></td>
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<tr>
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<td>STAB</td>
<td>STAB</td>
<td>STAB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 x 6½&quot;</td>
<td>STAB</td>
<td>STAB</td>
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<tr>
<td></td>
<td>STAB</td>
<td>STAB</td>
<td>SHOCK</td>
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## Jets

| | 16.16.16 | Run Float | 10.10.10 | CORE |
| Jet Velocity (fps) | 327 | Var. | 223 | |
| Pump Pressure (psi) | 950 | - | 500 | 150 |
| Pump Output (gpm) | 600 | - | 160 | 140 |
| Air (CFM) | - | 1800 | 50 - 60 | 45 - 55 |
| S.P.M. at 95% Efficiency | | | |
| Annular Velocity (DP/DC) | 171 / 136 | Var. | 165 / 292 | 144 / 255 |
| Bit H.H.P. (HHP/sq.in) | 2.50 | - | 1.03 | |
| Jet Impact Force (lbs/ft) | 893 | - | 129 | |
| Mud Weight (ppg) | 8.8 | Dry Air | 7.0 | 7.0 |
| Cumulative Rotating Hours | 12.00 | 66.00 | 111.00 | 115.50 |

## PUMP NUMBER

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### Remarks
- Flowrates can be reduced during circulation of samples or for suspected washed hole.
- Note 1: A Hammer and Hammer Bit may be used to drill this section with Air.
- Note 2: A Hammer and Hammer Bit may replace this bit run. Lower Pump Output for Foam generation/injection.

## Formation

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<th>KB Depths (m)</th>
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<tbody>
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<tr>
<td>Jinduckin Formation</td>
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<tr>
<td>Tindall Limestone</td>
</tr>
<tr>
<td>Antrim Volcanics</td>
</tr>
<tr>
<td>Hayfield Mudstone</td>
</tr>
<tr>
<td>Total Depth (TD)</td>
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**RECOMMENDED BIT AND HYDRAULICS PROGRAMME cont.**

**WELL: BURDO-1**

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<thead>
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<td>5.17</td>
<td>5.17</td>
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<td>860</td>
<td>1020</td>
</tr>
<tr>
<td>Out (m)</td>
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<td>1118</td>
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<tr>
<td>Total (m)</td>
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<td>40.0</td>
<td>40.0</td>
<td>40.0</td>
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<td>15 - 20</td>
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<td>70 - 90</td>
<td>70 - 90</td>
<td>70 - 90</td>
</tr>
<tr>
<td>B.H.A.</td>
<td>3 x 4%''</td>
<td>3 x 4%''</td>
<td>3 x 4%''</td>
<td>3 x 4%''</td>
</tr>
<tr>
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<td>9.10.BL</td>
<td>9.10.BL</td>
<td>9.10.BL</td>
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<td>370</td>
<td>370</td>
<td>370</td>
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<tr>
<td>*Air (CFM)</td>
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<tr>
<td>Annular Velocity (DP/DC)</td>
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<td>144 / 255</td>
<td>165 / 292</td>
<td>165 / 292</td>
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<tr>
<td>Bit H.H.P. (HHP/sq.in)</td>
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<td>2.83</td>
<td>2.83</td>
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<tr>
<td>Jet Impact Force (lbs/ft)</td>
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<td>214</td>
<td>214</td>
<td>214</td>
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<tr>
<td>*Mud Weight (ppg)</td>
<td>7.0</td>
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<td>7.0</td>
<td>7.0</td>
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<tr>
<td>Cumulative Rotating Hours</td>
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**PUMP NUMBER**

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<td>PUMP TYPE</td>
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<td>LINER SIZE</td>
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</tr>
<tr>
<td>80%</td>
<td>2090</td>
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</table>

**Formation**

| Antrim Volcanics | 298 |
| Hayfield Mudstone | 446 |
| Jamison Sandstone | 510 |
| Kyalla Member | 600 |
| Moroak Sandstone | 1118 |
| Total Depth (TD) | 1500 |

**Remarks:** Flowrates can be reduced during circulation of samples or for suspected washed hole.

**Note 3:** This section will be drilled with Air to 50-100m above the Jamison Sst and then the hole will be mudded up.

**Note 4:** Air Injection rate required at the standpipe to reduce 8.5 - 9.0ppg MW to 7.0ppg.

**Note 5:** Mud Weight reduced from 8.5 - 9.0ppg by Air Injection at the standpipe.
RECOMMENDED BIT AND HYDRAULICS PROGRAMME cont.

<table>
<thead>
<tr>
<th>BIT NUMBER</th>
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<tr>
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<td>1250</td>
<td>1270</td>
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<td>120</td>
<td>130</td>
</tr>
<tr>
<td>R.O.P. (m/hour)</td>
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<td>Hours</td>
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<td>15 - 20</td>
<td>15 - 20</td>
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<td>R.P.M.</td>
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<tr>
<td>B.H.A.</td>
<td>3 x 4½&quot; JARS</td>
<td>3 x 4½&quot; JARS</td>
<td>3 x 4½&quot; JARS</td>
<td>3 x 4½&quot; JARS</td>
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<td>Core Bbl</td>
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<td>11 x 4½&quot; 14 x 4½&quot;</td>
<td>11 x 4½&quot; 14 x 4½&quot;</td>
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<td>Jet Velocity (fps)</td>
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<td>Pump Output (gpm)</td>
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<tr>
<td>4Air (CFM)</td>
<td>70 - 85</td>
<td>85 - 115</td>
<td>95 - 125</td>
<td>100 - 135</td>
</tr>
<tr>
<td>S.P.M. at 95% Efficiency</td>
<td></td>
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</tr>
<tr>
<td>Annular Velocity (DP/DC)</td>
<td>144 / 255</td>
<td>165 / 292</td>
<td>165 / 292</td>
<td>165 / 292</td>
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<td>Bit H.H.P. (HHP/sq.in)</td>
<td>2.83</td>
<td>2.83</td>
<td>2.83</td>
<td></td>
</tr>
<tr>
<td>Jet Impact Force (lfs/ft)</td>
<td>214</td>
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<td></td>
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<tr>
<td>6Mud Weight (ppg)</td>
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<tr>
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PUMP NUMBER

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<td>LINER SIZE</td>
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<tr>
<td>NOMINAL DISCHARGE (gps)</td>
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<tr>
<td>RATED PRESSURE: 100% 80%</td>
<td>2610 2090</td>
</tr>
</tbody>
</table>

Remarks: Flowrates can be reduced during circulation of samples or for suspected washed hole.

Note 4: Air Injection rate required at the standpipe to reduce 8.5 - 9.0ppg MW to 7.0ppg.

Note 5: Mud Weight reduced from 8.5 - 9.0ppg by Air Injection at the standpipe.
CRA Exploration Environmental Policy

As part of the CRA Group, CRA Exploration Pty. Limited abides by the requirements of CRA Group Environmental Policy (refer Attachment A).

Key elements underlying CRA environmental policy are:

- the proper management of mineral and other resources, on which the Group's activities are based;
- adding to the store of such resources by exploration, research and development;
- developing appropriate rehabilitation programmes for exploration and operating sites;
- conserving raw materials and energy;
- providing for the safe handling and disposal of wastes;
- managing, appropriately, effluent's and emissions; and
- pursuing recycling programmes.

In implementing CRA environmental policy, CRA Exploration will manage its activities so as to ensure that they are environmentally sound, incorporating consideration of environmental concerns at all stages in the decision making process. Accordingly, CRA Exploration will comply at all times with the legal and regulatory consent requirements of governmental authorities and, where compliance with legal requirements is considered to be insufficient for any particular operation or activity, will adopt higher standards.

In addition CRA Exploration will promote consultation with landowners, local communities and government bodies to ensure a full understanding of natural and cultural resources and their usage, and encourages continuous improvement in operational practices to prevent or reduce environmental impact.
Statement of
CRA Group Environmental Policy

The CRA Group supports the concept of sustainable development - meeting the needs of this generation without closing off options for future generations.

For us, this means:

- exploring for new resources;
- developing better ways to process and use our products;
- conserving materials and energy;
- recycling and minimising waste.

Our objective is to manage together the development of resources and the protection of the environment.

Accordingly we will:

- maintain consistently high standards of environmental planning and management;
- comply with legal requirements;
- adopt higher standards where considered necessary;
- anticipate changing community values and be alert to technical advances which may improve environmental standards;
- ensure that all employees work to improve continuously our environmental performance;
- monitor regularly our environmental performance and ensure that proper management procedures are in place to meet our responsibilities.

We will communicate readily with the community, especially the people who live and work closer to our operations. We want to take their concerns into account, and we want them to understand our approach to environmental management.
121⁄4" HAMMER DRILL TO 60m

81⁄2" ROTARY DRILL WITH AIR to 353.0m

6" ROTARY DRILL WITH AIR/AERATED MUD/MUD TO 1500m

60m

SAND AND CLAY
JINDUCKIN FORMATION 64.9m
JINDUCKIN FORMATION 203.9m
TINDALL LIMESTONE 302.9m
ANTRIM VOLCANICS 418.9m
HAYFIELD MUD 484.9m
JAMISON SANDSTONE 574.9m

353.0m

PRIMARY TARGET

SECONARY TARGET

KYALLA MEMBER

1155.9m

PRIMARY TARGET

MORDA K

T.D. 1500

9½" casing to 6m.0m
7" casing to 353.0m
Provisional 5" casing to 1500m

Notes
Consider air and aerated mud drilling through main hole. Consider deviating hole through all or part of main hole.
Severe circulation loss can be expected in the Jinduckin Formation and Tindall Limestone.
PEI23

PROPOSED LOCATION
BURDO 1

VEGETATION MAP UNIT
8 - Stringybark, Darwin Woolly Butt and Rusty Bloodwood woodland
10 - Stringybark woodland
20 - Variable barked Bloodwood low woodland
22 - Bloodwood and Box low woodland
23 - Silver Box low woodland
24 - Coolibah and Gutta-percha low woodland
31 - Variable-barked Bloodwood and Stringybark low open woodland
32 - Variable-barked Bloodwood and Darwin Woolly Butt low open woodland
45 - Bauhinia, Silver Box low open woodland
55 - Lancewood open forest
98 - Golden Beard Grass and Bluegrass grassland


PR1993-0129
Rig Up

Drill 12½'' hole, run 9½'' conductor

Drill 8½'' hole with air

Run 7'' surface casing
Install BOPs

Drill 6½'' hole with air.
Circulate over to aerated mud
Cut core No.1, Conduct DST No.1

Cut core No.2 conduct DST No.2

Drill 6'' hole to T.D.
Log, P&A or set casing.

DEPTHS BELOW KELLY BUSHING
(depth in metres)

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600

DAYS FROM SPUD

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30