DRILLING CHECKLIST

DATE: ____________________________
SHIFT: ____________________________
OPERATOR RIGHT: __________________
OPERATOR LEFT: ___________________
DIESEL USED: _____________________

<table>
<thead>
<tr>
<th>DRILLED HOURS (LEFT)</th>
<th>DRILLED HOURS (RIGHT)</th>
<th>METERS DRILLED LEFT</th>
<th>METERS DRILLED RIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. CHECK ENGINE & CARRIER

1. Parking Brakes on
2. Damage & leaks to Engine
3. Wheels: Condition
   Pressure
   Studs
   Hubs
4. Hydraulic Oil level
5. Engine Oil level
6. Transmission Oil level
7. Fan Belts
8. Engine Mountings
9. Water Tank Full
10. Diesel Tank Full
11. Air Cleaners are clean
12. Fire Extinguisher available

B. CONTROL PANEL AND BOOMS

1. All levers centralised before starting
2. Check all Hydraulic hoses
3. Check Steering: Engage & Disengage
4. Check Chain feed
5. Check Boom Telescopic
6. Check Chain Tension
7. Check Chain Sprockets
8. Check Chain Feed Slide (damaged)
9. Check All Cylinder Pins
10. Check cylinder for leaks
    Lift Cylinder
    Tilt cylinder
    Slew cylinder
    Boom Rotation
11. Check for loose nuts or fittings
12. Check drifter mountings and hoses
13. Check Shank
    Coupling
    Rods
    Rod Clamps
14. Check rubber buffer (damage)
C. START ENGINE

1. Run engine for 2 minutes before moving
2. Check jacks - front & back
3. Turn both booms drifters to inside position

PREPARE TO DRIVE RIG

1. Operator walking ahead
2. Operator driving
   Sound horn on bends

D. CABLE & CABLE REEL

1. Check Plug & Plug socket
2. Check Plug is properly connected into feeder

   Connect up air & water
   Blow out hoses before connecting up TO RIG.
R.E.G.M. (Cooke 2. Shaft)

Trackless Mining

Special Instruction for

Drill Rig Operators

1. A drill rig is to be used for drilling only. It is not to be used for transporting people (other than the operator and instructor when applicable) or any other material.

2. Under no circumstances are the booms to be used for a platform.

3. Whilst travelling in a decline or incline, the booms of the rig are to face updip (engine and cable reel on downgrade side of decline/incline).

4. Whilst a drill rig is travelling in a decline or incline, no person is to be allowed on the downdip side of the machine.

K.A. Rhodes
Manager Mining
Cooke 2

W.A. Hillyard 17/11/9
1. **Daily Servicing** (Attached)
   Each unit will be given to the artisan in charge for a minimum period of 1 hour per shift. The machine will be checked and serviced. All minor defects will be rectified.

2. **Weekly Servicing** (Attached)
   All units will be serviced weekly and be steam cleaned during the weekly service. Planned maintenance will also be done during this period.
   N.B. Any parts used or replaced on any unit, or any time loss for breakdowns must be recorded on service sheets and on operator's checklist. These records must be submitted to the M.E.S. daily.

---

K.A. Rhodes
Manager Mining
Cooke 2

[Signature]
19.12.94
# Daily Service and Artisan Report:

**Shift:**  
**Date:**  
**Unit:**  
**Eng. Hours:**  
**Time In:**  
**Time Out:**  
**Driver's Signature:**  
**Driver's Signature:**  

## Check Points

<table>
<thead>
<tr>
<th>Check</th>
<th>Yes</th>
<th>No</th>
<th>Oil Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Oil Level</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Trans Oil Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HYD Oil Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brakes Oil Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check for Oil Water Leaks - Air</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure Gauges</td>
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<td></td>
</tr>
<tr>
<td>Engine Running</td>
<td></td>
<td></td>
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<tr>
<td>Steering</td>
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<td></td>
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<td>Transmission</td>
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<td></td>
</tr>
<tr>
<td>Brakes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Hydraulics</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Check for Loose Bolts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tyres Pressure</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Grease Boom Pins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grease Articulation Pins</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Remarks:

Please report all parts used.

---

**Artisan**
THE RANDFONTEIN ESTATES GOLD MINING COMPANY, WITWATERSRAND, LIMITED

WEEKLY SERVICE: HOURS 60: HOURS 180: HOURS 240: HOURS 480

UNIT: EVERY FRIDAY

HOURS: FROM: 7.00 a.m. - 11.00 a.m. ON 60 Hrs.
TIME IN: FROM: 7.00 a.m. - 12.00 a.m. ON 180 Hrs.
TIME OUT: FROM: 7.00 a.m. - 12.30 p.m. ON 240 Hrs.
FROM: 7.00 a.m. - 1.00 p.m. ON 480 Hrs.

1. CLEAN UNIT
2. CLEAN ENGINE
3. GREASE BUCKET PINS
4. GREASE BOOM PINS
5. GREASE DRIVES SHAFT
6. GREASE ARTICULATION PINS
7. GREASE AND LUBRICATION ON ACCELERATOR LINKAGE
8. GREASE AND LUBRICATION ON GEAR SHIFT LINKAGE

ENGINE:

1. CHECK OIL LEVEL Topped IF NECESSARY
2. CHECK FOR OIL OR FUEL LEAKS
3. CHECK CONDITION ON V BELTS. ADJUST IF NECESSARY.
4. CHECK TIGHTNESS OF THE ENGINE BRACKET BOLTS
5. CHECK AIR CLEANER. DUST CONTAINER
6. CHECK ENGINE IDLER AND FULL RPM ADJUST IF NECESSARY.

TRANSMISSIONS, TORQUE CONVERTOR:

CHECK FOR LEAKS
CHECK OIL LEVEL
CHECK BRACKET BOLTS
CHECK DRIVE SHAFT
CHECK OIL PRESSURE

TEST TRANSMISSION:

OIL USED
SPARES USED
TRACKLESS MINING: COOKE 2

2.7m LONG x 25mm DIA.
FULL COLUMN RESIN GROUTED REBAR

CONTOUR DRIVES AND ROADWAYS (SUPPORT SYSTEM): TMC 2/10

SCALE 1: 200

K.A. RHODES
MANAGER MINING

COOKE 2
DEC. 1984
ANNEXURE 3.11

“Wide Reef Mechanised Room and Pillar Operations at Cooke 2 Shaft, Randfontein Estates Gold Mining Company, Witwatersrand Limited”

by K.A.Rhodes

Published in the Transactions of the Association of Mine Managers of South Africa in 1986

K.A. RHODES
Project Manager, H.J. Joel Gold Mining Company, Limited

SYNOPSIS
Planning for a mechanised room and pillar system at Cooke 2 Shaft commenced in late 1983, trackless equipment being introduced in mid-1984. In early 1986, the planned production rate of 40 000 tons per month will be achieved from the operation utilising a full fleet of equipment.

The operation is technically successful and will be economically viable. This mining method with mechanised equipment is proving to be a safe system for the exploitation of a wide reef.

This paper details the main design parameters for the room and pillar operation; discusses the cycle of operations on the reef horizon; defines the equipment in use and the factors considered for the selection of the equipment.

The importance of the training and engineering functions and management commitment to a mechanised operation are constantly stressed.

INTRODUCTION
In early 1983, wide reef stoping operations commenced at Cooke 2 Shaft on two reef horizons: the UEIA Reef and the underlying E8 Reef. The method of mining initially introduced was the bord and pillar system, but this was later superseded by the room and pillar method. These operations proved successful and have enabled the mine to exploit certain low grade ore reserves profitably due to improved efficiencies causing a significant reduction in working costs.

Nevertheless, in late 1983, it was believed that further significant improvements in productivity could be gained by the introduction of trackless equipment on the reef horizon and, therefore, motivations for a mechanised operation were submitted in late 1983/early 1984.

In July 1984, development of an area of E8 Reef with trackless equipment commenced at Cooke 2 Shaft; this development programme was the first phase (Phase 1) of the operation and was considered experimental. In December, 1984, Phase 2 of the operation was motivated which would provide for a planned production rate of 40 000 tons per month in January 1986.
The main objectives of these motivations were therefore:
(a) To improve productivity by a major reduction in manpower.
(b) To increase profits because of lower labour complements; a significant reduction in development costs; partial elimination of ancillary operations.
(c) To provide for a safer operation.

GEOLOGY

The area selected for the mechanised operation was a block of E8 Reef between 85 Level and 95 Level in the north-eastern portion of the lease area of Cooke 2 Shaft. In this area the E8 Reef varies in width between 2 metres and 5 metres, with a general dip of between 2° and 10° in an easterly direction and, further, is relatively undisturbed.

The geology of the area must, therefore, be considered favourable for the operation of trackless equipment on the reef horizon. Figure 1 is a plan of the area showing the 200 cms isopach, strike lines and major faults; Figure 2 shows a transverse section through the area.

MINING DESIGN

Production Parameters

It was envisaged at the planning stage that the maximum planned production from the operation would be 40 000 tons per month on a double shift basis; this rate of production to be achieved by January 1986. The mineable reserves in the area have been estimated at approximately 3 million tons and, therefore, the life of the operation is considered to be in excess of six years.

Rock Mechanics Considerations

Certain rock mechanics recommendations were made before operations commenced and are detailed as follows:

Overstopping

The UEIA Reef lies 20 metres to 40 metres above the E8 Reef horizon and, in order to maximise the percentage extraction of E8 Reef, it is essential that maximum extraction of the overlying UEIA Reef be achieved; observations in previously mined wide E8 Reef conventional stopes had shown that any highly loaded pillar on the UEIA Reef horizon had necessitated that larger than standard pillars be left on the underlying E8 Reef horizon in order to ensure stope stability.

Regional Pillars

All regional pillars on the UEIA Reef horizon would have to be superimposed on identical regional pillars on the E8 Reef horizon.

Primary and Secondary Extraction

It was planned prior to the introduction of trackless equipment in wide reef stopes that extraction would take place in two stages; this principle being established when the system of mining changed from bord and pillar to room and pillar.
The sequence of primary and secondary extraction operations has definite major advantages as follows:
(a) The pillars initially developed in the primary operation will be larger than required, and will, therefore, have a high factor of safety.
(b) The maximum recommended room spans on the E8 Reef horizon have been determined as 10 metres on advance (primary extraction). However, these spans can be allowed to exceed 10 metres during a secondary extraction stage in a retreat operation when the worked-out areas will then be abandoned and barricaded.

**Pillar Size and Percentage Extraction**

When the E8 Reef has been overstopped, the E8 Reef horizon will be destressed; computer analyses have indicated an average vertical stress of 50% of the virgin overburden stress. Pillar widths of 1 to 1.5 times the stoping width will be stable and it is planned that pillar sizes during primary mining will be 7 metres x 10 metres with the final size of pillars following the secondary stage being 5 metres x 5 metres. Final extraction is expected to be 90%. However, it must be emphasized that no unnecessary pillars should be left on the UEIA Reef horizon as this condition would prove detrimental to overall percentage extraction on the E8 Reef horizon and, in this respect, when the final geometry on the UEIA Reef horizon is known, computer analyses will be conducted in order to determine any high stress areas on the E8 Reef horizon.

**General Mining Layout**

Development of the area commenced on the 90 Level elevation; initially contour reef drives were developed from the 90 N II Crosscut North and from these drives reef declines were developed at approximately 150 metre centres.

In this layout all development is carried out on the reef horizon, with the exception of a workshop complex (in close proximity to the operation) and the footwall haulage development.

Footwall development consists of a crosscut developed from the 101 Level Haulage and out of this crosscut a 2.4 metre diameter orepass (raiseborer hole), 110 metres in length. This orepass will serve as the only main tipping point for the life of the operation; however, in the event of an orepass blockage, other alternative tipping points can be made available.

Footwall waste development for the project is, therefore, minimal. If conventional reef operations had been allowed to take place, it would have been necessary to develop 10 000 metres of footwall development for the same reserve.

**Primary Development**

All contour drives are developed 8 metres wide and 4 metres high. Declines, if developed on true dip of the reef, have dimensions 10 metres wide and 4 metres high; where the dip of the reef exceeds 10°, declines are developed on an apparent dip of 10° and are 8 metres wide and 4 metres high. Figure 3 shows the general development layout.
**Primary Stoping**

The method of mining selected for this operation is the stepped room and pillar system. In this system the stope rooms are developed on strike 10 metres wide and are mined as two 5 metre wide panels with stepped floors; the lower panel known as the P1 panel is mined as a development heading and leads the P2 panel or slashing panel by approximately 8 metres. Access holings are made between rooms at 60° down dip of strike at 14 metre centres. The detailed layout of the rooms and pillars is shown in Figure 4.

Stoping only commences when the access decline holes into a bottom access airway.

**Secondary Extraction**

Secondary extraction will be carried out when primary stoping operations are complete from any access decline. During secondary extraction operations partial extraction of pillars will take place on retreat; pillars will be reduced in size in stages to the minimum dimensions. The stages in the partial extraction of pillars is shown in Figure 5.

**Ventilation**

The total volume of air required to satisfy all criteria for this project, including double shift multi-blast stoping operations (fixed time blasting at the end of each shift) is 140 m³/sec.

Stopes faces are ventilated by air jet fans operating in conjunction with force fans and flexiduct tubing. Figure 6 shows a sketch of the stope ventilation layout.

Double shift stoping has not as yet been introduced, but it is envisaged that a three hour re-entry period at the end of each shift will be approved by the Inspector of Mines in terms of this layout and the overall ventilation reticulation.

**Cycle of Operations**

**Drilling and Blasting**

All faces (development and stoping) are drilled by electro-hydraulic two boom drill rigs.

For blasting operations Nonel Long Period delays (L.P.D.s) are used in the P1 leading panel and Nonel Short Period Delays (S.P.D.s) are in use for the P2 slashing panel; for development operations the 8 metre wide ends are also being advanced as for a stoping panel.

Blasting with Nonel has improved fragmentation and the throw of the blast is highly effective for L.H.D. cleaning; more than 85% of the P2 blast is thrown into the P1 panel. An additional advantage from Nonel has been its use with long rounds (3, 8 metres) drilled by the electro-hydraulic drill rigs where improved efficiencies have been achieved.

**Cleaning Operations**

Cleaning operations to date have been carried out by L.H.D. units into
locomotive hoppers; such a method being a major constraint. However, the system has been necessary during the development stage and build-up to full production whilst awaiting the construction of the main tipping arrangements and ore clearance system; these installations are now nearing completion and in January 1986, reef will be trammed by dump truck to a main tip equipped with an impact pedestal breaker before transfer to 101 Level to the high capacity streamlined gathering haulage.

The L.H.D. units (3.8 m³ bucket size) will load into the dump trucks (18 ton and 32 ton) in the access declines where height is available; however, loading into trucks should take place as close as practicable to the working face, taking cognisance of working height and dip of the orebody. Trucks are faster and less expensive to operate than L.H.D. units and, therefore, it is advantageous to reduce the tramming distance of L.H.D. units to a minimum.

All arterial reef roadways are developed 8 metres wide to allow for two vehicles to pass each other without the necessity for passing loops.

Figure 7 details the layout of the main tip area and Figure 8, details of the tip grizzley steel.

Support

The recommended support system being used in development and stopping operations consists of 2.7 metre long, 25 mm rebar, with full column resin on a 2 metre square pattern. The standard support systems for development and stopping rooms are shown in Figure 9 and 10 respectively.

All roofbolt holes are drilled by a separate roofbolter unit (single boom and basket).

In certain areas it has been necessary to install 40 ton x 6 metre long cable anchors as additional support in the main arterials following recommendations by the Rock Mechanics Engineer; rock mechanics officers conduct regular audits of the main arterial support in terms of a management instruction.

During secondary extraction, when operations are being carried out on retreat, it may not be necessary to install the above standard of support and support recommendations will then depend on actual experience.

Waste Packing

Waste packing has been successfully carried out in certain worked-out rooms; the primary objective of early stopping operations was to enable waste from workshop development to be packed in the underground workings, notwithstanding the experience gained from these initial stopping operations.

EQUIPMENT

Selection

Several factors were considered before the final selection of the equipment for the operation and these can be discussed as follows:

(a) Size

In general the largest size unit has been purchased for the reason
that the selection of the largest size unit will achieve a reduction in working costs by reducing the number of machines in the fleet; operating costs are reduced because the cost of operating different sizes of units does not show a marked variation and the number of artisans is less because the ratio of units to one artisan does not vary with the size of the unit. Notwithstanding the above, cognisance must be taken of the optimum size of the fleet and also the dimensions of the workings.

(b) Access of Equipment to Mine

All equipment to the trackless area must be transported down Cooke 2 Main Shaft and along 90 Level Haulage; the dimensions of the compartments of this shaft dictate that all equipment must be stripped on surface and re-assembled underground.

Before any equipment was considered for selection, full documentation of the details of the dimensions and mass of all the components and sub-assemblies of such equipment were compiled in order to confirm that the equipment could be transported through the shaft to the working place.

(c) Specifications

When asking for tenders for any piece of equipment, the responsible engineer compiled a detailed specification document to be issued with the enquiry.

(d) Adjudication

When all tender documents were received and forwarded to the mine for final adjudication, an adjudication committee was set up consisting of managers and engineers (including Industrial Engineering Department) and an evaluation was carried out; the various equipment being evaluated on a points system in accordance with certain major parameters, such parameters varying with the type of equipment.

Equipment Fleet

The full fleet of equipment for the planned production rate of 40 000 tons per month is summarised as follows:

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>No. of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electro-hydraulic Drill Rig (2 Boom)</td>
<td>4</td>
</tr>
<tr>
<td>Roofbolter (Boom and Basket)</td>
<td>2</td>
</tr>
<tr>
<td>L.H.D. (2.7 m³)</td>
<td>2</td>
</tr>
<tr>
<td>L.H.D. (3.8 m³)</td>
<td>3</td>
</tr>
<tr>
<td>Dump Truck 18 Ton</td>
<td>2</td>
</tr>
<tr>
<td>Dump Truck 32 Ton</td>
<td>2</td>
</tr>
<tr>
<td>Utility Vehicle</td>
<td>3</td>
</tr>
<tr>
<td>Grader</td>
<td>1</td>
</tr>
<tr>
<td>Land Cruisers</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total Units:</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

Some brief comments on the above equipment follow:
Drill rigs

The electro-hydraulic drill rig was selected at an early stage in planning this operation. Major advantages of the hydraulic rig against the pneumatic rig are:

(a) Advance rates are maximised due to faster penetration rates.
(b) Pneumatic rigs require high air pressures even necessitating the installation of booster compressors.
(c) Reduction in use of compressed air and thereby reducing energy costs.

Roofbolter

In order to comply with the requirements of the recommended support system (2.7 metre grouted rebar) it is necessary to drill a 2.8 metre roofbolt hole; three alternative methods of performing this operation were identified which are:

(a) Use of the standard drill rig necessitates a working height of 4.8 metres to operate the rig; this alternative not being acceptable in terms of the channel widths in the reserve as it is necessary to mine at a stoping width of 3 metres with the selected equipment.
(b) Use of a telescopic chain feed with the drill rig, which is common in tunnelling operations. However, a stoping width of 3.6 metres is required to drill a hole of 1.8 metres and, therefore, this option was also unacceptable.
(c) Introduction of a separate roofbolting unit. In terms of this option, a 2.7 metre hole could be drilled in two passes in a minimum stoping width of 3.1 metres or in three passes in a stoping width of 2.5 metres. This option was, therefore, selected.

Notwithstanding the above, the introduction of a separate roofbolter in a cyclic operation, where several working places are available and where roofbolting is a major operation in the cycle, has a definite advantage in that the face drill rig can be released to carry out the main function for which it was designed; only captive machines should be allowed to operate as multi-purpose units.

L.H.D. units

For the Phase 1 period of the operation 2.7 m$^3$ size L.H.D. units were purchased but, in terms of the argument for the selection of the largest size unit, the 3.8 m$^3$ size unit was selected for Phase 2.

A further development in Phase 2 has been the introduction of ejector buckets to the 3.8 m$^3$ units. Ejector buckets are necessary to facilitate the loading of the trucks (height restriction) and further to obviate damage to the truck body due to the height of the truck and to prevent damage to truck wheels and tyres. When an L.H.D. unit moves into position next to a truck for conventional loading without an ejector bucket, it approaches too close to the truck and contact with the truck is then unavoidable.
Trucks

It is essential that L.H.D. units and trucks are matched and also that the optimum number of L.H.D. passes will fill the truck; the 18 ton truck will be filled by four passes of the 2.7 m³ unit and the three passes of the 3.8 m³ units whilst the 32 ton truck will be filled by five passes of the 3.8 m³ unit.

At this time the bowl of a 35 ton carrying capacity truck is being fitted with a rubber lining providing for an unconditional guarantee of two years. Considerable attention has been given to this matter before opting for a rubber lining as against steel liners and, in terms of the guarantee and expected bowl wear, a considerable saving can be expected; after installation of the lining the actual capacity of the truck will be 32 tons.

The 18 ton dump trucks were imported as a unit and no change has been made to these machines.

A future development could be the installation of a suspended rubber bowl in a steel frame; such a body has been successfully introduced to an 18 ton dump truck at Otjihase (Tsumeb Corporation S.W.A./Namibia), where previously all bowls were equipped with rubber linings.

Utility vehicles

Utility vehicles are vital as back-up equipment in a mechanised operation. These vehicles are in use throughout the shift in a wide reef operation for face inspection; barrin down and making safe; charging up; drilling suspension holes; hanging pipes and cables.

An important lesson to be learned is that when performing the above ancillary operations in a cyclic operation, where several working faces are available, it is essential that loading units (L.H.D.'s and trucks) and drilling units (drill rigs and roofbolters) are used continuously for the purpose they were designed; such equipment is considerably more expensive to purchase (than a utility vehicle) and has a higher operating cost and, further, the utility vehicle is specifically designed for the ancillary operation. The introduction of units designed for specific tasks in a cyclic operation is, therefore, logical.

Grader

Considerable attention must be given to roadbed conditions in a trackless operation and systematic grading of the arterial roadways will be carried out by the grader when this unit is made available in January 1986. Raiseborer cuttings have been imported to the operation to provide for a final surface; potholes being filled in with crushed rock (-50 mm).

It cannot be recommended that an L.H.D. unit performs the duty of grading roadbeds for the reason that the argument for utility vehicles is still applicable (the grader is in fact a utility vehicle).

Personnel vehicle (land cruiser)

Effective supervision and back-up service by Engineering and other