The evolution of Mines Rope Rescue in Mines Rescue Services - South Africa

Abstract: This paper describe the evolution of rope rescue principles used by Mines Rescue Services (Pty) Ltd in South Africa over the past 14 years.

Introduction

For more than 70 years Mines Rescue Services specialised in underground fires. Following an incident in 1993 where 104 persons were trapped in the bottom of a single outlet shaft, it was decided to expand our service to the mines by including rope rescue techniques. Initially training was provided by outside contractors and we implemented the different techniques and used the different types of equipment in training, on ore-pass entries and rescues underground, predominantly in our gold mining industry.

After using these techniques during rescue operations, we concluded that the majority of the techniques used were sporting or surface rescue orientated.

Certain equipment design, construction and materials used were found not to be suitable for underground use in our gold mining industry, due to the harsh conditions.

Mines Rescue Services South Africa then decided to develop, combine and adapt the best suited systems and equipment to meet our mining industries needs.

Mine Rope Rescue training in South Africa

Safety:

The safety of rescuer, patient, incident commander and his assistant in close proximity to the point of entry must be observed at all times.
The safety of all persons on the site who are under the direct supervision and instruction of the incident commander must be observed at all times.

Systems:

All systems must be:

Double – every system must be backed-up by an independent system so that should one system fail, the second system can then take over.

Simple – the minimum amount of equipment and components should be used in building a system, yet it must be safe and effective.

All the systems that we have developed have been tried and tested in our training galleries as well as during underground trainings and rescues.

These systems have proved to be reliable, effective, fail proof, safe and adaptable to suit most situations.

Equipment:

Equipment must regularly be checked and where necessary certified.

The Mines Rescue Service's vehicle that proceeds to the incident must be fully equipped with the necessary equipment to cope with any rope rescue situation.

In certain cases a second vehicle would be dispatched with lifting and cutting equipment.

In the case of a major accident, equipment would be dispatched from the other rescue stations to the scene of the accident.

Research and development:

After every incident we objectively look at the systems and equipment currently being used as we are continually attempting to improve our systems.

If the equipment and systems currently used have shortcomings or don't fulfil the need, we then attempt to design, adapt, source, simulate, test and implement to cater for a similar situation in the future.

During a shaft accident in 1993 where our rescue teams were underground for up to five days, 104 persons were brought to safety. During this incident the Skyjack was introduced to speed the operation up.

The Mines Rope Rescue Technicians:

They must be fully trained current brigadesmen who are medically fit and heat tolerant.
All Mines Rope Rescue Technicians must have successfully completed the three day initial training as well as the bi-annual refresher training to be deemed competent.

They must have a good understanding of the application of the respective systems to meet the specific need and conform to the minimum standards.

It is a definite advantage if the Mines Rope Rescue Technicians have knowledge of and practical experience in shafts and ore-passes, ground conditions and the associated dangers.

Normally between eight to twelve Mines Rope Rescue Technicians are required during an incident, depending on the circumstances.

On arrival all Mines Rope Rescue Technicians must submit their training registers and declarations of fitness.

When on site the respective tasks will be delegated amongst the members present. The Incident commander and his assistant must have managerial skills, have knowledge, experience, leadership and be qualified in Basic Live Support. He must also have the ability to continually evaluate, identify and overcome dangerous situations. He must be self confident and be able take control of the situation.

The scribe must be a competent Mines Rope Rescue Technician and should be familiar with all mining, Basic Live Support and Mines rope rescue terminology as well as have the ability to record comprehensive minutes of the complete operation from commencement to end.

Mines Rope Rescue Technicians who have been instructed to take charge of setting up the systems, must be competent.

The Mines Rope Rescue Technician, who is going to be lowered down the hole, should preferably not have worked a shift in hot working conditions prior to the callout and he must volunteer to be lowered. He must also be qualified in Basic Live Support and he must be able to continually assess the situation determining whether it is safe to commence. His mental status must be taken into account.

Site assessment:

The first Mines Rope Rescue Technician at the scene of the accident would do the following:

- Do a quick assessment and determine the magnitude of the problem, try to communicate with the person to be rescued reassuring the person that help is on its way.
- Raise the alarm and call for help, list of equipment requirements suitable to execute the rescue and a team of. Mines Rope Rescue Technicians.

A control should be setup to co-ordinate and organize the rescue so that the sequence of events flows smoothly.

Stop flow of ore from upper levels and place guards at strategic places.

Place a guard at the point of entry to prevent any tipping from taking place and lower a compressed air hose down the hole to ventilate the area to certain extent.

Push a compressed air hose into the box-front from the bottom and place a guard so that the box-front can not be opened.

Extend communication as close as possible to the incident.

Clear the access ways for quick entry of men, equipment and evacuation of the injured.

Clear any loose rock or material away from the hole ensuring that persons are secured and that nothing falls down the hole.

Investigate whether any changes can be made to the ventilation to improve conditions where the rescue is going to take place and whether it necessary to delay blasting operations due to blasting fumes, concussion and possible seismic events.

Only keep sufficient volunteers to assist and the remainder of the shift should be cleared to minimize the amount of people in the area. Union and health and safety representatives and other responsible people should remain on site to assist with the rescue.

Under no circumstances should one or two persons try to affect the rescue. Preparation, planning and setting-up of systems can commence but only after sufficient Mines Rope Rescue Technicians have arrived, should the rescue commence.

Equipment:

Equipment used by Mines Rope Rescue Technicians must be simple in design, easy to use, reliable, durable, light, safe, compact, robust, versatile and easy to wash as well as to maintain.

The equipment is packed in such a manner that it can be transported to the site on material cars or in extremely difficult cases in the carry bags on the backs of the rescuers.

The initial assessment will determine the systems to be used and the determining factor being access to the area. In the case of steeply inclined travelling ways and steep stopes, small, compact and lightweight systems will be used such as the Griptech. In the case of a shaft ore-pass that is easily accessible the Skyjack would be used.

The bags are packed in such a manner that by selecting the required length of rope and the applicable bag (for example the main line bag), the Mines Rope Rescue Technician would be able to complete a component of a system and only in extremely difficult cases would he be required to take additional equipment from the material line.

All the equipment is housed in a trailer that can be unloaded from four points of access in the case of an emergency.

The Mines Rope Rescue trailer is towed by a light delivery vehicle which is equipped with stretchers, underground communication systems, cooling garments, gas monitoring, medical and measuring equipment as well as PPE bags, frozen water , long duration self rescuers, a tripod , sealing equipment, ore-pass nets ,short shovels, wedges, air movers, air hose and fittings.

Each Mines Rope Rescue Technician takes his own PPE bag, food and liquid replacement with him in his personal haversack.

On completion of training or an incident all equipment is washed, dried, checked, packed, logged and stored in the rescue trailer. This trailer is pre-packed and kept in a state of readiness to reduce the response time.

Mines Rescue Services also have a rescue winder that can be used in the case of a shaft accident and can be used to a depth of one thousand meters.

Systems:

When we designed our systems we set minimum standards and this was done in the interests of health and safety.

The basic systems are adaptable and able to meet all the challenges we have faced in the past.

The rescuer that proceeds down the hole must continually assess the conditions, communicate, report to the incident commander and affect the rescue.

All the lowering and raising is affected by the remainder of the Mines Rope Rescue Technicians manning the respective systems, on direct instruction from the Incident Commander who is in continual contact with the rescuer.

All systems are checked by the incident commander and the Mines Rope Rescue Technician in charge of that system prior to the rescuer being lowered. All parties must give their approval and this must be recorded.

If communication between the incident commander and the rescuer is lost at any stage, the rescuer is immediately raised up to the point of entry.

At no stage from descent to ascent should the rescuer be detached from the main or belay line.

Anchors:

All anchors must have at least two independent anchor points that are capable of carrying the full load of the rescuer and the person to be rescued.

Critical angles must be taken into consideration and the attachment of the system must be as close to the anchor as possible.

The anchor points must be suitably elevated to accommodate the system and must be suitably aligned with the self directing pulley above the point of entry.

Mainline:

The main line will consist of the Skyjack with applicable length of 9mm steel rope or the Griptech with applicable length of 11mm static kernmantle rope with a mechanical advantage in place.

The system should preferably be in direct sight and hearing distance of the Incident Commander.

In the case where a mechanical advantage is going to be used adequate re-set distance must be taken into consideration.

If the distance between the Incident Commander and the Mines Rope Rescue Technician is excessive a communication system must be installed.

The men, material and systems must be protected from rolling stock.

If necessary the electrical power, water and compressed air should be isolated. Consideration should be given to stop the conveyances in the shaft if in close proximity to the shaft.

Belay line:

The belay line will consist of a Griptech with the applicable length of 11mm static kernmantle rope and in the case where the Skyjack is used on the main line, a mechanical advantage must be in place.

The rope on the belay line should preferably be a different colour to the main line rope.

The system should be set up in such a manner that it does not cross the main line preferably in the opposite direction to the main line but in sight of the Incident Commander and within hearing distance.

If the distance is excessive between the Incident Commander and the Mines Rope Rescue Technicians in charge of the belay line and the mechanical advantage, communications must be installed.

Adequate reset distance must be taken into account in the case where a mechanical advantage is to be installed.

Environmental conditions:

Equipment for the measurement of temperature and the testing of flammable gas, Carbon Monoxide and the deficiency of oxygen must be used.

In the case of deficiency of oxygen or the presence of other gases or fumes, long duration self rescuers should be available.

If at all possible the area should be ventilated to cool the area down and minimize the presence of build-up of gases or fumes.

The rescuer:
The rescuer must have a full body harness on at all times. When applicable the full body harness must be used in conjunction with the trapeze and spreader bar.

He will be attached to the main line and the belay line at all times.

He will have at least two effective means of communication between himself and the Incident Commander.

He will be lowered and raised on request working through the Incident Commander who in turn will instruct the Mines Rope Rescue Technicians in charge of the main line and the belay line. He will rest in a cool place and hydrate while his fellow Mines Rope Rescue Technicians set the systems up and check the respective systems.

Discussion of two underground rescues:

Rescue No.1:

Attached find the facts and sketches explaining the situation where a person fell into an underground silo and was trapped by ore.
The problems that we faced, the decisions made by all present including the trapped person.

Sketch A:

The profile of the ore, the width of the underground silo and the amount of ore made it logistically impossible to consolidate the ore and concentrate our efforts around the trapped person to free him.
The profile of the ore could have changed at any time.
A certain amount of loose ore gravitated down to the trapped person as rescuers gained access to the trapped person.
Taking the amount of ore into account it would have taken in excess of eight days to remove this ore from the silo using bags. To further complicate this matter there were big rocks in the ore.
It was estimated that between thirty and sixty tons of ore would have to be removed from the silo to enable us to free the trapped person.
Any spillage or rolling rocks could injure the trapped person so he would have to be protected by means of constructing a cage around him.
Consideration was given to use an industrial vacuum cleaner. This was not possible due to the fact that no vacuum cleaners were readily available, rocks in the ore, vertical distance of between fifteen and thirty meters and dust. All the persons in ore pass would have to have breathing protection.

Sketch B & C:

The anterior portion of the patient was against the hanging wall and he said it felt as if his legs were not straight but trapped in the ore. The patient had lost a lot of blood, was in a state of shock and he had no feeling in his legs. He was conscious and he could communicate with us.
The rescuers managed to remove some ore from the side of the trapped person and place it behind their backs.
The rescuers then freed the patients left arm and he managed to assist them in attaching pickoff straps onto his cap lamp belt. An open harness was secured around his thorax and left thigh. Numerous attempts were made to pull him from the ore by means of a mechanical advantage but with no success. The patient found this to be very painful. This also confirmed that his legs were trapped in the ore below him.

By this stage of the rescue very little progress in freeing the patient had been made. The patient's condition was deteriorating and he was becoming very despondent and requested that we consider opening the box and drain the ore in an attempt to free him.

Sketch D:

After assessing the situation and considering all possibilities as well as consulting with all parties present, including the trapped person, it was decided to slowly draw the ore from the box. Communication between Underground Control and persons at the box front was established and an open line was maintained.
The box front was bled slowly and no movement of ore was reported by the rescuers. A sudden movement of ore occurred and the profile of the ore changed dramatically, trapping the legs of the one rescuer and totally engulfing the trapped person. The slack was taken up on the ropes attached to the rescuers and they reported that they had lost communication with the trapped person. It was then decided to continue pulling the box to free the rescuers legs and to try to expose the trapped person as soon as possible in an attempt to save his life.
We unfortunately lost the trapped person as he was drawn into the ore and his body was recovered out of the box on the belt level.
After this incident a workshop was held and it was decided to design, develop and construct a rescue cage to attempt to overcome the problems should a situation like this occur in the future.
This cage would enable us to concentrate our efforts to free the trapped person from the ore and offer a certain amount of protection to the trapped person.
The rescue cage would be erected around the trapped person and airbags or props would be used to push the top of the rescue cage against the hanging wall of the ore-pass.
The ore that is loaded can then be deposited on the sides of the rescue cage.
The design is such that the sides retain the loaded ore and the inner sections are lowered as you dig down.
If we had this rescue cage we possibly could have saved the life of the trapped person.
This situation was unique in the sense that the area inside the silo was vast, the ore profile was unpredictable and in excess of the normal angle of repose.
The other option was to attempt to dig the trapped person out which could take days.
The critics all said we should have tried to dig him out and if we then lost him they would have said that we should have pulled the box.
I firmly believe that the decisions made taking all the factors into consideration were made in the interests of the trapped person giving him the best chances of survival.

Rescue No.2:

Attached find the facts and sketches explaining the situation where a person was drawn into an ore-pass by loose stuff, was totally engulfed and rescued after twelve hours of digging.

Step No. 1:

If you compare this situation to the previous rescue, the ore could be consolidated and the area made safe as we progressed with the rescue.

Step No.2:

A human chain could be formed and the ore only had to be transported for ten meters. Approximately four tons of ore was taken out of the ore-pass.

Step No.3:

After twelve hours of digging and rotating positions in the human chain to optimize efficiency, the trapped person could be brought to a point of safety.

Practical training:
We try to do our refresher training underground as this is as close to reality as possible. Regular exercises are performed by using up to twelve Mines Rope Rescue Technicians to perform ore-pass examinations. These are conducted to check for self mining, scaling, restrictions and build-up of mud or fines. All the necessary documentation is completed and safety precautions are taken.

We have also simulated a full conveyance that has been pulled into the jack catches and the evacuation of seriously injured persons.

In conjunction with management we simulated an accident in a sinking shaft as well as the evacuation of patients in a kibble.

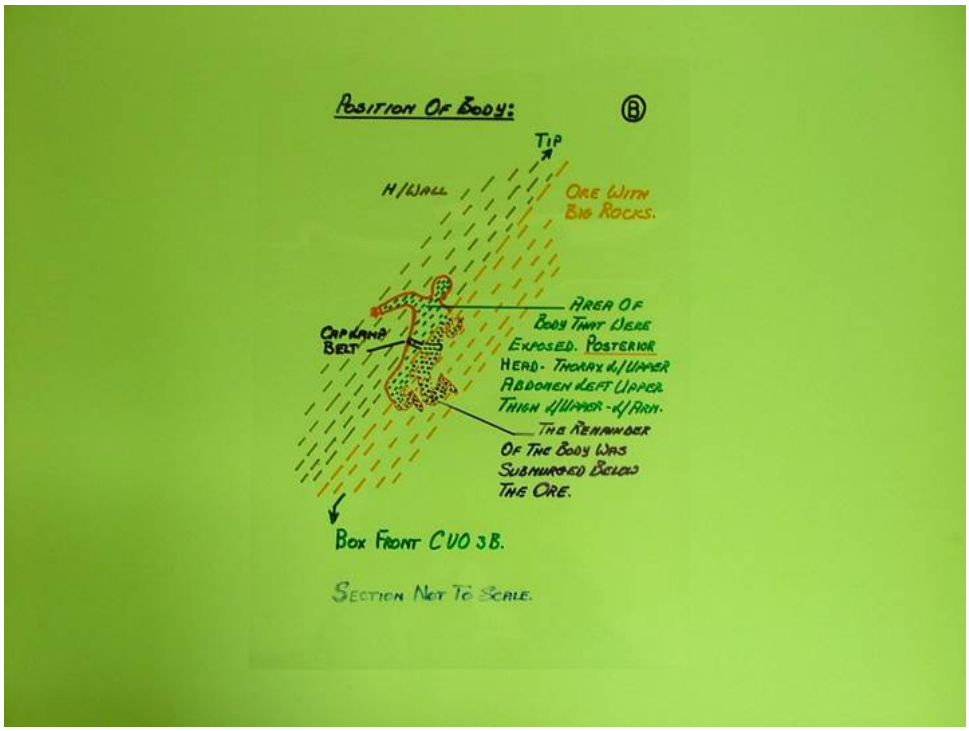
The rescue winder has also been used to examine redundant shafts and ventilation shafts up to a depth of nine hundred meters.

Annexures attached:

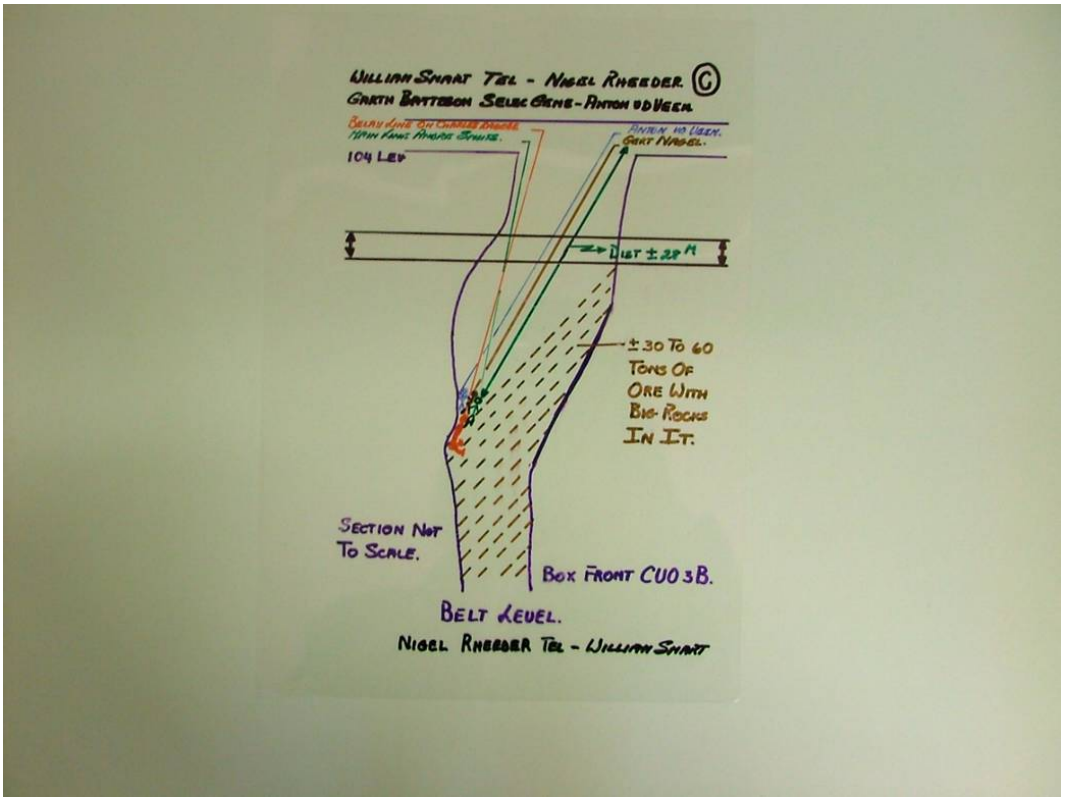
A sketch of the rescue cage and a copy of the document used when we do a planned inspection on a mine are attached.

Rescue No.1 Sketch A

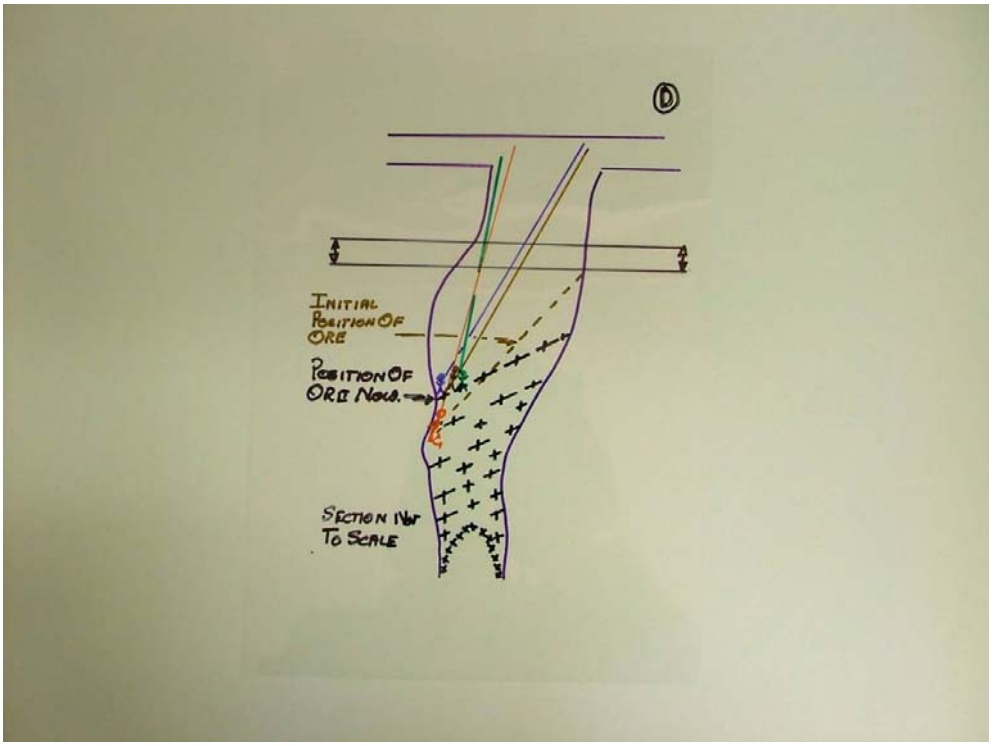
Rescue No.1 Sketch B



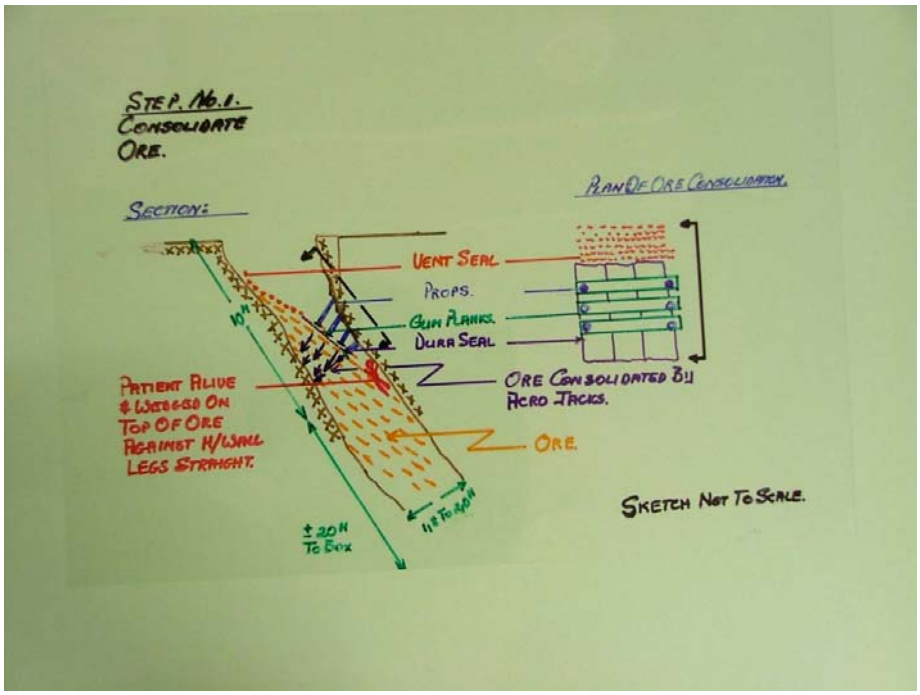
Rescue No.1 Sketch C



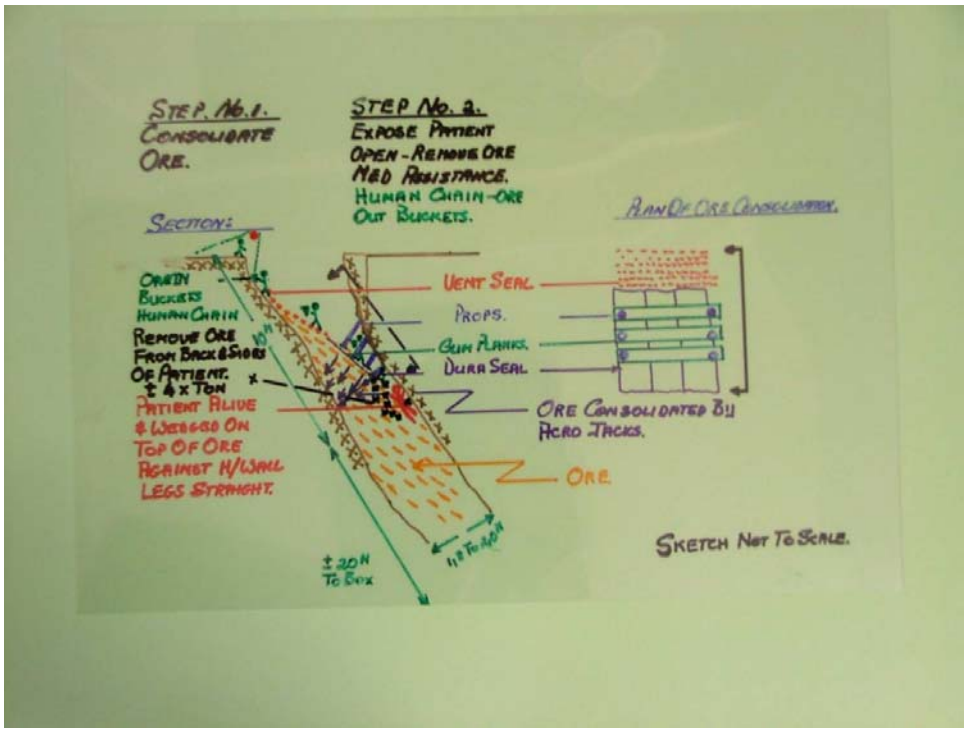
Rescue No.1 Sketch D



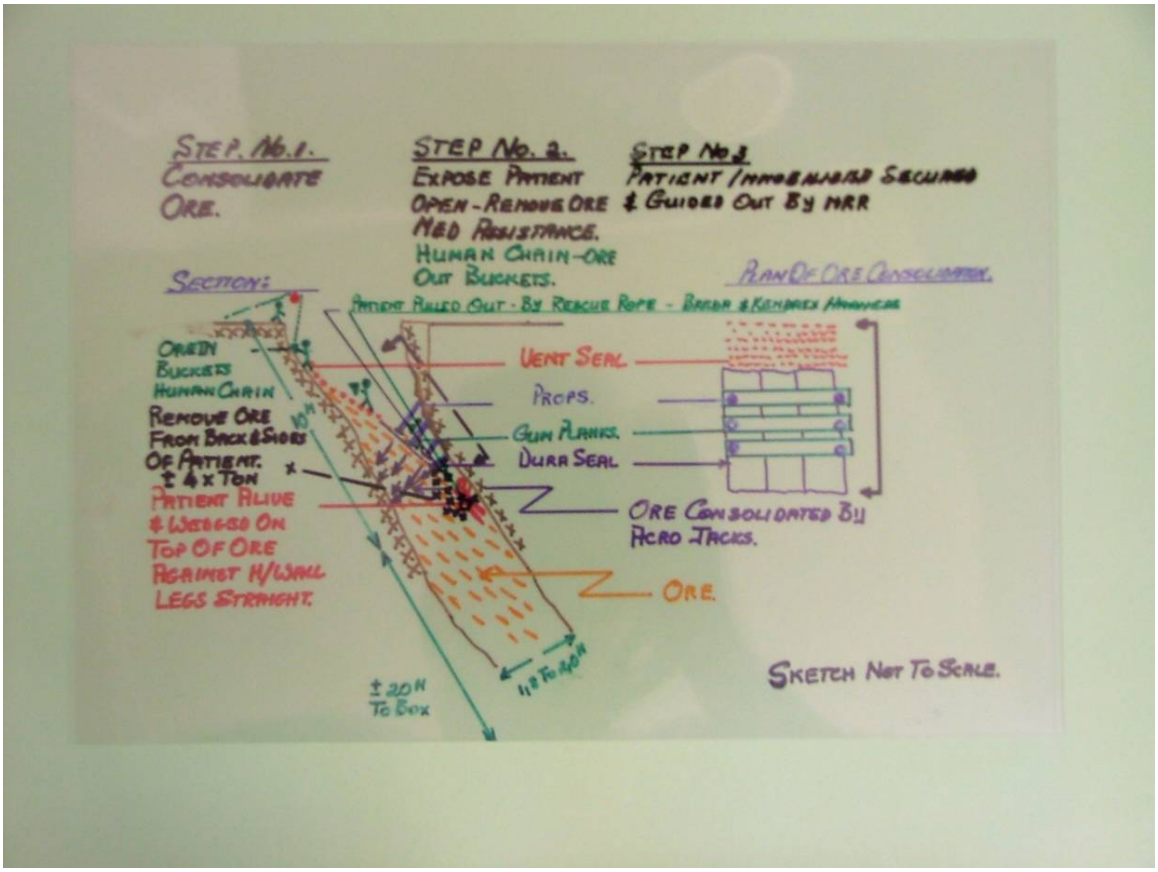
Rescue No. 2 Step No.1



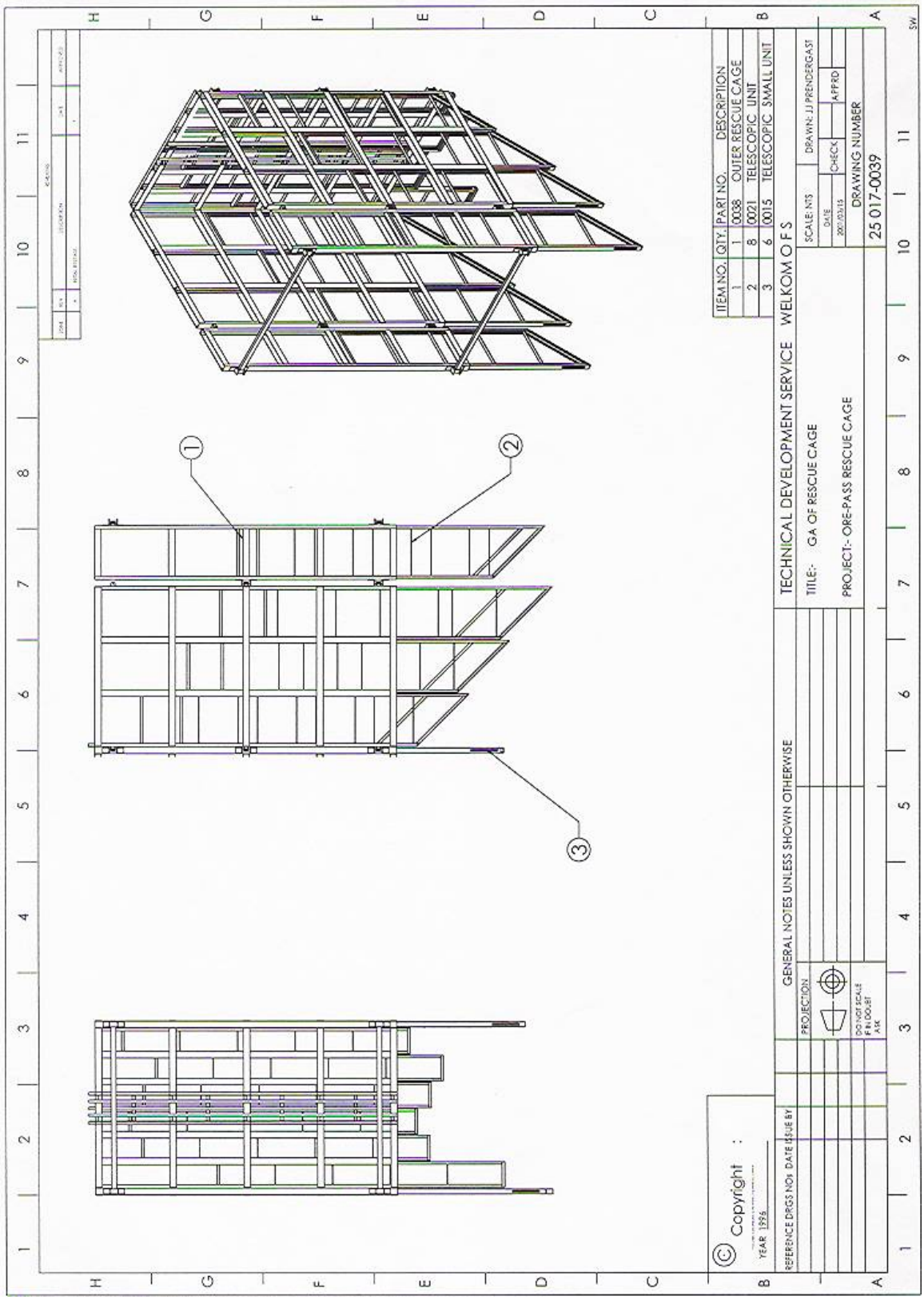
Rescue No. 2 Step No.2



Rescue No. 2 Step No.3



Rescue Cage


ITEM NO. QTY. PART NO. DESCRIPTION
1 1 0038 OUTER RESCUE CAGE
2 8 0021 TELESCOPIC UNIT
3 6 0015 TELESCOPIC SMALL UNIT
TECHNICAL DEVELOPMENT SERVICE WELKOM O F S
TITLE:- GA OF RESCUE CAGE
PROJECT:- ORE-PASS RESCUE CAGE
SCALE: NTS
DRAWN: JJ PRENDERGAST
DATE
CHECK
APPRD
DRAWING NUMBER
25 017-0039
GENERAL NOTES UNLESS SHOWN OTHERWISE
PROJECTION
DO NOT SCALE FROM DRAWING ASK
REFERENCE DRGS NOS DATE ISSUE BY
© Copyright :
YEAR 1995
1
2
3

MINES RESCUE SERVICES

Welkom

PRE Inspection **DATE:** _____ **TIME:** _____

MINE: _____

SHAFT: _____

LOCATION: a: _____

b: _____

c: _____

d: _____

PERSONS TO BE PRESENT AT PRE INSPECTION

1) Legally appointed person. A) Name: _____

2) Two MRR persons B) Name: _____

C) Name: _____

Equipment Required for Pre Inspection

	Checked
1) 2 x Full body harnesses	
2) 2 x Retractible lanyards	
3) 2 x Spotlights and batteries	
4) 2 x Spray paint or chalk	
5) 1 x Location plan	
6) 1 x Section	

OBJECTIVE

It must allways be considered that this objective could possibly not be met due to conditions found within the ore pass.

ORE PASS DESIGN AND SAFETY

POINTS OF ENTRY

Does the system continue to the level above?
Y-Leg ?

Control shute closed:
Decked over and secured:
No tipping from above:
Guards placed & appointed:
At tipping points:

Plug of ore to be left in ore pass:

Who will do preparity work ? NAME:_____

Is the Grizzely clear of Rocks, Mud, Ore.
All loose material around area
Removed

Area washed down
Stop blocks on rails either side of ore pass

Who will do preparity work ? NAME:_____

Notes:

RIGGING

Anchor points for :	Main line	Belay line	Material line	Incident commander
Above hole				
Side wall				
Footwall				
Improvised				

NB: At least two anchor points per attachment as above.

The anchor points must be Bombproof.

Safety: a) Hanging wall / Side wall / Foot wall condition.

b) Proximity to ore pass, services and rolling stock.

Who will do preparity work ? NAME: _____

Ventilation

Through Ventilation on level?				
Through Ventilation through ore pass?				
Possibility of blasting fumes?				
Possibility of gas?				
Is breathing apparatus required?				
Ore pass to be empty.				
Explosive Atmosphere ?				
Burning permission requirements:				

Who will do preparity work ? NAME: _____

Notes:

MATERIALS REQUIRED

Mines own equipment complete as per MRS equipment
MRR equipment complete
Camera
Distometer
Plan
Section
Rigging equipment
Lighting
Removal and isolation of overhead trolley lines

Who will do preparity work ? NAME: _____

PERSONS TO BE PRESENT DURING EXAMINATION:

Legaly appointed person:
Legaly appointed Engineer:
MRR Incident Commander:
MRR Technichians:

NB
The following to be checked in order for all MRR technicians:
a) Medical in blue books.
b) All training to be up to date.
c) MRR refresher training to be in order.
d) Declaration of fittness to be completed.
e) PPE bags to be available.
f) BAA bag to be available.
g) All proto ancilliary equipment required.
h) Ex-Gratia documentation signed by Manager and Engineer

OPTIONAL:

Rock Mechanics
Geology
Survey
Shaft
Guards
Other persons to assist

Documentation:

1) MRS / 017/F037 Rescue Team Ex-Gratia Payment
2) MRS / QM / F031 Fire Incident Report data Form
3) MRS / QM / F039
4) MRS / QM / F038
5) No No Instructions
6) All Doc Pages 1 to 5
7) Notes and or minutes taken by scribe.

CONCLUSION:
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We have never attended a rope rescue that was not unique; each rescue comes with its own challenges. There is nothing more gratifying than seeing the face of the person being rescued when they have been brought to a point of safety.

It is only by the grace of God & his protecting hand that is over our proto men as they volunteer to proceed down these ore-passes to rescue people that have fallen into them or have been drawn in with the ore.

I would like to thank all the dedicated MRS staff members who get involved in the rescues. They continually strive to improve the current systems & if necessary introduce new equipment or systems to overcome problems.

YOURS IN RESCUE,

GARTH BATTESON.
SUPERINTENDENT.
MRS WELKOM.