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New Concept Mining (Pty) Ltd
Company Reg. No. 2001/012336/07
PO Box 125000 Alrode 1451
109 Adcock Ingram Ave. Aeroton
South Africa
Fax: (011) 494 1060
Tel: (011) 494 6000
E-mail: ncmweb@ncm.co.za

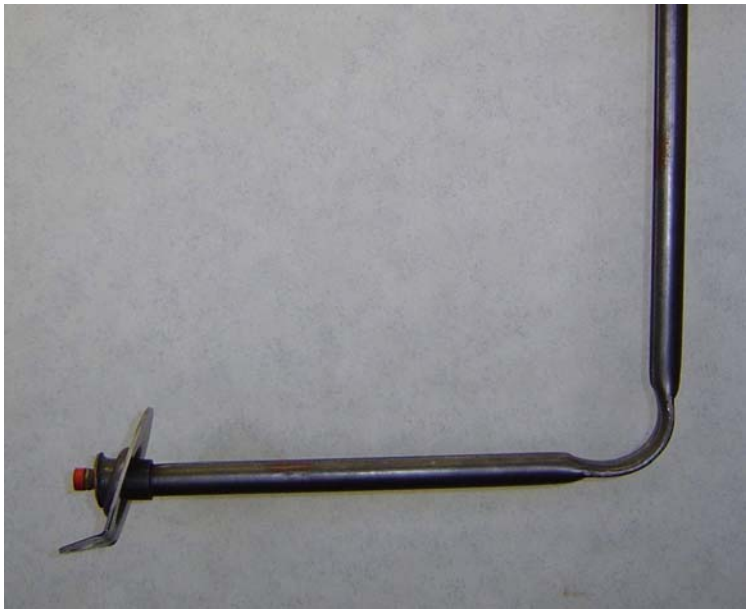
*Guideline for the compilation of a**

Risk Assessment

on the

RS Bolt (Bent Hydrabolt) *Pre-Stressed*

Rock Anchor



**This guideline has been prepared by New Concept Mining (Pty) Ltd to assist a user in the compilation of its own Risk assessment as required by the Mine Health and Safety Act.*

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1 Summary

1.1 Introduction

This guideline has been prepared by New Concept Mining (Pty) Ltd to assist any mine using the RS Bolt pre-stressed Rock Anchor in compilation of its own risk assessment as required by section 11 of the Mine Health and Safety Act. The assessment has been undertaken by the supplier in terms of the requirement of section 21 of the Act.

This Risk assessment has been undertaken by staff of New Concept Mining who have been involved in the design, manufacturing and marketing of the unit to establish the risks associated with the use of the product.

This support unit is also designed to assist mines, where applicable, to comply with Chapter 14 of the Mine Health and Safety Act in terms of the new generation regulatory mechanisms Chapter 14.1 (7) refers to Competent person B who has the responsibility for the installation, removal and maintenance of support

1.2 Key Risk Issues

Arising from the assessment and analysis were the following main key risk issues:

- The underground environment and particularly the risk associated with falls of ground due to poor hangingwall conditions that may exist during the installation process.
- The inadequate installation of the anchor, which may lead to removal of the support by the blasting process with potential impacts of falls of ground. These installation conditions are characterized by insufficient preload pressure that will provide less than expected pull out forces.

1.3 Recommendations

The following recommendations have been made:

1. The user should develop, implement and maintain appropriate procedures and training programmes for the correct and safe installation of the RS Bolt by its operating personnel.
2. The user's rock engineering department must be aware of and approve the use of the RS Bolt as compatible with existing support strategy.
3. Appropriate personal protective equipment (PPE) should be provided to all persons installing the unit (e.g. gloves, eye protection)
4. Appropriate pressurising equipment should be provided and authorised for use in the pre-stressing of the RS Bolt during the installation.

2 Objectives

The purpose of this risk assessment is:

To identify the hazards, prioritise the associated risks and highlight the controls required to eliminate or minimise the risks related to the RS B**olt Pre-Stressed Rock Anchor** and its operation, as well as any risk of failure, primarily from the point of view of the health and safety of the workforce, but also production delay and asset damage or a combination of the three.

This process ensures that all reasonable precautions are taken to either eliminate or minimise the risk of injury to the workforce during the installation or operating phases.

The outcome is a formal Risk assessment Report with prioritised actions where applicable.

3 Risk Analysis Method

The risk analysis follows a standard method of work process analysis. All risk assessments follow a general scheme, which can be described as follows:

1. Description of the system under analysis (including equipment, personnel, procedures, work environment, management and supervisory systems) etc.
2. Identification of loss scenarios (i.e. sequences of events leading up to potential or actual losses such as incidents or accidents) in the form of hazards, potential productivity interruptions, asset damage events, environmental contamination issues etc. and evaluation of the risks of each loss scenario by determination of the relative likelihood of each event, and the relative consequence of each event.
3. Evaluation of the currently planned controls, barriers and safeguards, including a post control risk rating.
4. Identification of additional controls, barriers and safeguards.

3.1 Defining the operational system

The report is scoped to review risks related to the work process during the storage, transport and installation of the RS Bolt. An operational flow chart highlighting these activities is derived within the risk assessment.

The performance of the unit was also examined by way of a Failure Mode and Effect Analysis (FMEA) on the component parts of the system. This appears in Appendix B.

3.2 Identification of the possible system hazards

This step postulates the maximum reasonable consequence of loss scenarios (i.e. of circumstances leading up to or resulting in hazards). The consequences were classified as losses to people (health & safety), production delays, equipment and environmental damage, or combinations of these losses.

In the current study, the focus is on the health & safety issues.

3.3 Determination of the level of risks

Risks associated with each step in the operational flow chart are considered. This is achieved by

considering the event frequency (probability) and the event severity (consequence).

In South Africa, Sigma Risk utilises a standard ranking system that has been used on many previous analyses, and has been acknowledged by international authorities as an acceptable means of prioritising and ranking risk-based information during team exercises.

The definition of risk: - **Risk is defined as the product of probability and consequence.**

The ratings of probability and consequence used in this assessment are shown below.

3.3.1 Probability categories

Probability categories (A - E) were defined as follows.

Category	Probability
A	Common
B	Likely to happen
C	Could happen
D	Unlikely
E	Extremely unlikely (Practically impossible)

Table 1- Probability Categories

3.3.2 Consequence categories

Consequence categories (1 - 5) were defined for various loss categories as follows.

Category	Health & Safety consequence
1	Fatality / fatalities
2	Major Injury
3	Average Lost Time Injury
4	Minor Injury
5	Medical treatment only, or less

Table 2 - Consequence Categories

3.3.3 Risk categories

Risk categories are defined by combining the probability and consequence categories above according to a matrix of prioritised risk ranking as follows. For each hazard, an assessment of probability and consequence was carried out. The risk rating was then derived using the following risk matrix.

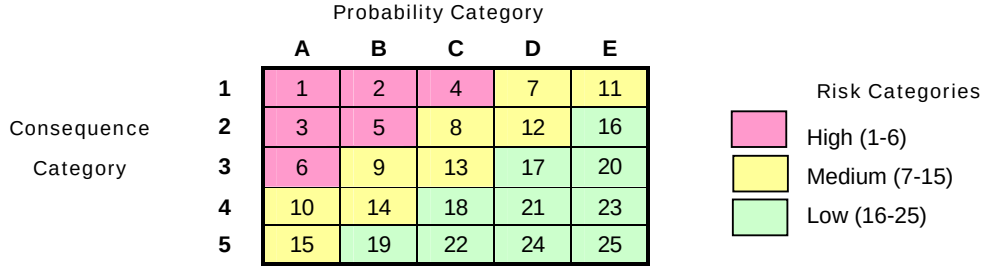

Figure 1 - Risk Matrix

A risk score of 1 denotes the highest (most significant) risk. A risk score of 25 denotes the lowest (least significant) risk.

Each risk rating was then grouped into high, medium or low categories, according to the grouping above. High risks are those ranked 1 - 6 on the matrix, and medium risks are those which ranked 7 - 15. Low risk hazards may be analysed at a later date, but are considered to be of an acceptable level.

3.4 Definition and description of the system controls and barriers

This step identifies existing controls and barriers, and also considered planned and possible additional controls and barriers, which could be used to manage the operational risks. Controls and barriers include engineering devices, operational methods and practices, management actions and principles, and environmental and system amendments that the team agrees appropriate to consider.

Controls are assessed for all the hazards identified in the Work Process Analysis (WPA).

3.5 Assessment of the acceptability of the controls

The acceptability of the nominated controls in terms of design devices, management and operational practices and system amendments is reviewed to ensure that additional scope for risk reduction has not been overlooked within the time available. An assessment of the residual risk rating after the implementation of existing controls is made. Hazards still found to carry an unacceptably high risk rating are the subject of further assessment and additional measures are recommended where appropriate.

3.6 Documentation of the study process and results

The report is presented so that the user can review the planned and proposed controls and barriers and can devise an implementation plan to incorporate any additional approved controls established through the risk analysis.

4 Results

The risk analysis exercise generated a structured set of results presented in this section.

4.1 Format for results

The analysis is based on the flow chart of work activities and the component parts of the equipment.

Results are presented in the following sequence.

- System description
- Flow chart
- Component list
- Risk analysis tables

4.2 System description

The RS B**olt Pre-Stressed Rock Anchor** is supplied to users of rock support anchors to apply

clamping and anchoring of the rock surrounding an underground excavation at the time of installation in areas were a longer bolt than the stoping width is required. This is enabled through the application of hydraulic pressure to the unit, which is sealed steel container shaped in the form of a collapsed tube and bent at 45 or 60 degrees at a point along the bolt. It is placed in the previously drilled support hole. As the RS Bolt is installed it is straightened and then pushed into the hole and then held in place by hand whilst hydraulic pressure is applied by means of a suitable pump. The pump is connected to the unit by a hose that clips on to the non-return valve on the end of the RS Bolt. The RS Bolt is pressurised to a minimum 20 MPa, which is sufficient for the RS Bolt to generate 10 tons load carrying capacity from a critical bond length of 300mm. (8 tons from 200mm with the NT version)

Two dimensions are available. 26mm and 29mm in diameter un-inflated to and inflated diameter of 37mm and 41mm respectively. The wall thickness is 2,3mm and 2mm respectively. The unit has a mass of 2 kg per meter length. The above sizes have a guaranteed breaking load of 10 tons.

A second option is available in the 26mm diameter (referred to as the Hydrabolt NT range) with a wall thickness of 1,9mm and a guaranteed breaking load of 8 tons.

The assessment considers the associated risks involved with the transport, storage and installation of the RS Bolt as shown in the flowchart in Figure 3.

4.3 The flowchart of work activities

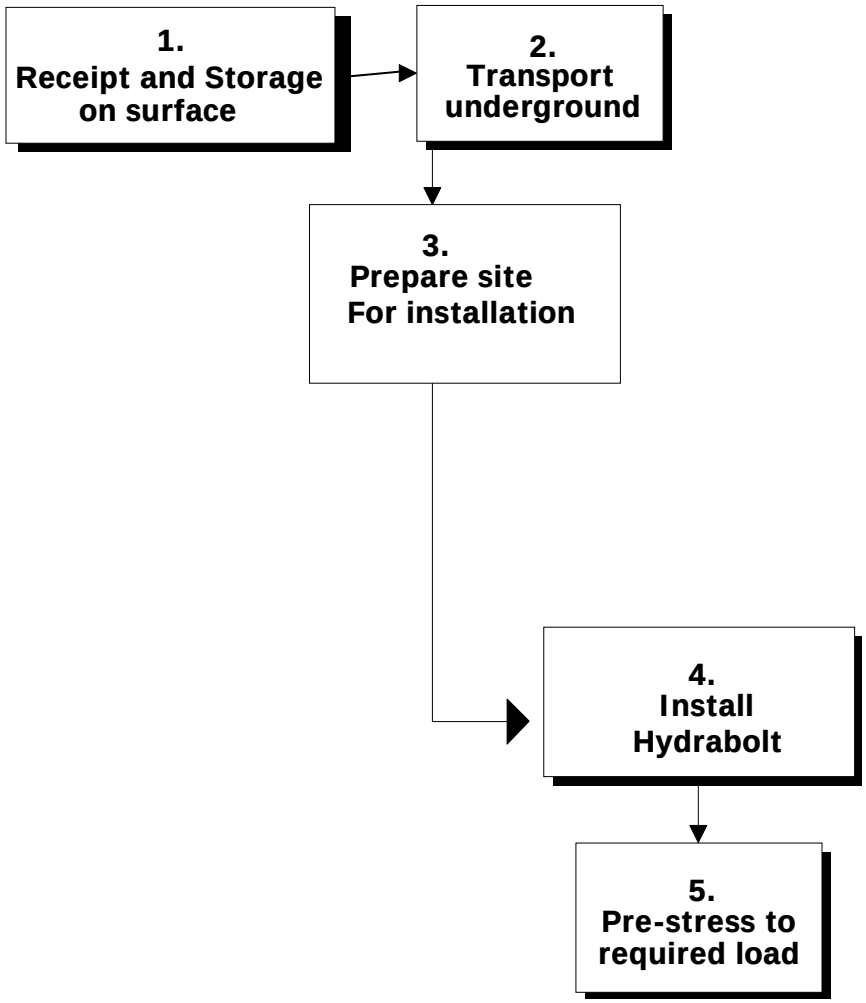

Figure 2 - Activities falling within the scope of this assessment

4.4 Component List

1. Steel body
2. Pressurising valve
3. Steel washer

A failure mode and effects analysis was carried out on the various components as identified and results are tabulated in the table in Appendix B.

4.5 Hazards

Based on the table of results of the assessment the following principal hazards have been identified in the handling, storage and installation of the RS Bolt. These constitute the higher risk areas as rated using the risk matrix in 3.3.3 above.

4.5.1 Use in the underground environment

RS Bolts are used extensively in the underground environment as rock anchors. This is often a systematic application, which requires regular, frequent and repetitious installation requiring continuous exposure to the hazards of the hanging wall and sidewall in a variety of conditions. As the principal hazard is a fall of ground, a potentially life threatening occurrence, this represents the highest risk to users of the RS Bolt and must be taken into account when determining the level of controls required to mitigate this risk.
At present, the corrosive resistance of RS Bolt has not been tested and therefore the RS Bolt is not recommended for long term or permanent support.

4.5.2 Installation issues

A number of hazards are highlighted in the installation process. These focus on the potential for incorrect installation of the RS Bolt that will normally result in inadequate load setting and potential falls of ground. Installing the RS Bolt with insufficient pre-load pressure, or not installing the correct length of RS Bolt in a support hole of sufficient length can cause this. RS Bolts must be installed at an angle as close to 90 degree's as possible to the strata, angles lower than this will result in inadequate support and potential falls of ground

5 RS Bolt Installation Procedures

5.1 Installation of unit using either a High Pressure Air Pump, Jackpot Hand Pump or a third party pump

5.2 Installation using Jackpot Safety Pistol and High Pressure Air Pump (Blue)

1. Examine and make safe the area where the installation will take place
2. Install temporary support as per mine standard
3. Prepare the hanging wall to drill the support holes.
4. Mark off and drill the required holes in the hanging-wall according to your mine standard. As close to 90 degrees as possible to the strata
5. Check the RS Bolt for any damage to the tube and the valve.
6. Assemble the washer onto the RS Bolt.
7. Insert the RS Bolt into the hole until the bend is approximately 100mm from the hole of the mouth.
8. Start straightening the bolt slowly until about 20 degrees to go or until the bend wants to kink.
9. Insert the bolt further into the hole until the bulge on the bend is at the entry to the hole, straighten some more.
10. Insert the bolt as far into the hole as it will go and straighten completely.
11. Hold in place, if necessary, with hand.
12. Remove the red plastic cap from the valve.
13. Check that the valve is clean and free of dirt, clean with water if required.
14. Fit the Hydrabolt nozzle onto the valve.
15. Compress the handle on the safety pistol and start pumping water into the RS Bolt.
16. As soon as the RS Bolt starts expanding move away and pressurize the RS Bolt from a safe position.
17. Continue pumping until the safety pistol squirts water out the relief valve (20Mpa).
18. Release the handle on the Safety Pistol to relieve the pressure in the hose and then remove the nozzle from the RS Bolt and check that the load indicator is visible.
19. Prepare for the next installation.

Pump the bolt immediately after installation and not at the end of the shift or at some other convenient time.

5.3 Installation using Jackpot Hand Pump

1. Examine and make safe the area where the installation will take place
2. Install temporary support as per mine standard
3. Prepare the hanging wall to drill the support holes.
4. Mark off and drill the required holes in the hanging-wall according to your mine standard. As close to 90 degrees as possible to the strata
5. Check the RS Bolt for any damage to the tube and the valve.
6. Assemble the washer onto the RS Bolt.
7. Insert the RS Bolt into the hole until the bend is approximately 100mm from the hole of the mouth.
8. Start straightening the bolt slowly until about 20 degrees to go or until the bend wants to kink.
9. Insert the bolt further into the hole until the bulge on the bend is at the entry to the hole, straighten some more.
10. Insert the bolt as far into the hole as it will go and straighten completely.
11. Hold in place, if necessary, with hand.
12. Remove the red plastic cap from the valve.
13. Check that the valve is clean and free of dirt, clean with water if required.
14. Fit the Hydrabolt nozzle onto the valve.
15. Manually Pump water into the RS Bolt until it starts expanding and then move away to a safe position and pump until water squirts out the relief valve (20Mpa).
16. Continue pumping until the safety pistol squirts water out the relief valve (20Mpa).
18. Release the handle on the Safety Pistol to relieve the pressure in the hose and then remove the nozzle from the RS Bolt and check that the load indicator is visible.
19. Prepare for the next installation.

Pump the bolt immediately after installation and not at the end of the shift or at some other convenient time.

5.4 Installation using a Third Party pump.

1. Ensure that the third party pump is compatible to the Jackpot Combi Nozzle.
2. Ensure the third party pump can pump the required pressures (20MPa to 30MPa)
3. Although other pumps can be used it is recommended that New Concept Mining equipment and accessories are used as they were designed in conjunction with each other and insure the correct installation of NCM products.

1. Examine and make safe the area where the installation will take place
2. Install temporary support as per mine standard
3. Prepare the hanging wall to drill the support holes.
4. Mark off and drill the required holes in the hanging-wall according to your mine standard. As close to 90 degrees as possible to the strata
5. Check the RS Bolt for any damage to the tube and the valve.
6. Assemble the washer onto the RS Bolt.
7. Insert the RS Bolt into the hole until the bend is approximately 100mm from the hole of the mouth.
8. Start straightening the bolt slowly until about 20 degrees to go or until the bend wants to kink.
9. Insert the bolt further into the hole until the bulge on the bend is at the entry to the hole, straighten some more.
10. Insert the bolt as far into the hole as it will go and straighten completely.
11. Hold in place, if necessary, with hand.
12. Remove the red plastic cap from the valve.
13. Check that the valve is clean and free of dirt, clean with water if required.
14. Fit the Hydrabolt nozzle onto the valve.
15. Compress the handle on the safety pistol and start pumping water into the RS Bolt.
16. As soon as the RS Bolt starts expanding move away and pressurize the RS Bolt from a safe

position.
17. Continue pumping until the safety pistol squirts water out the relief valve (20Mpa).
18. Release the handle on the Safety Pistol to relieve the pressure in the hose and then remove the nozzle from the RS Bolt and check that the load indicator is visible.
19. Prepare for the next installation.

Pump the bolt immediately after installation and not at the end of the shift or at some other convenient time.

5.5 Safety Tips and Hints

1. Always work from a supported/safe position
2. Always use Hydrabolt High Pressure Air pumps (Blue) or Hand Pumps to install RS Bolts
3. Always make sure you are wearing gloves and safety goggles when installing RS Bolt.s
4. Do not use RS Bolts if they have been damaged.
5. Check the relieving pressure on the safety pistol daily.
6. Repair any leaks on the installation equipment immediately (nozzle seal, hoses, safety pistol, etc)
7. Improper installation can result in poorly supported rock, which can cause severe injury or death.
8. The High Pressure air pump is supplied with a Hydrabolt / RS Bolt nozzle and a Jackpot nozzle so that both units can be installed with the High pressure pump
9. Never use a Low Pressure Jackpot Pump (Yellow) to install RS Bolt.
10. Always check that the load indicator is visible after installation which indicates that the RS Bolt has been pumped to the correct pressure.
11. Always make sure that the holes have been drilled at an angle of between 90 and 70 degree's to the strata

5.6 Controls

5.6.1 Design and manufacturing process

In the manufacture of the RS Bolt certain controls have been identified as having a positive effect on the control of the potential hazards. These include the correct Quality Assurance procedures for steel procurement, quality control checks in the manufacturing process, quality acceptance testing on all materials and components, air pressure testing of completed RS Bolt and high pressure testing of 1 percent of completed units.

5.6.2 Procedures

The use of the RS Bolt is directed through training programs offered by the supplier and assistance with the setting up of standard procedures for the transport and installation of the units in the workplace.

The user will normally be responsible for setting up its own procedures in the use of the unit in accordance with both the current safety procedures for the installation of support and the rock engineering requirements regarding the deployment of the support units.

5.6.3 Training

Training of the mine trainers by the supplier is offered to ensure that the units are properly installed by the safest possible means. The supplier also offers on-site training to assist in the accumulation of the proper skills by mine staff. It is recommended by the supplier that all operatives required to install the support unit are appropriately trained and assessed in the learning outcomes and assessment criteria of the applicable unit standard (MnH-G050) related to this support unit. This is an NQF level 2 unit standard and awards 4 credits to the learners

Persons credited with this unit standard are able to

-Explain the specific requirements pertaining to the installation of mechanical anchors

-Prepare to install mechanical anchors

-Install mechanical anchors

5.6.4 PPE

In the area of PPE, it is important that proper protective equipment is issued to those either transporting or installing the Hydrabolt. This should include safety boots, gloves and eye protection.

Appendix A - Table of Risk Assessment Results

	AREA / ACTIVITY /	HAZARD	CONSEQUENCE / EFFECT	PRE-CONTROLS RISK INDEX			EXISTING SAFEGUARDS / CONTROLS	POST-CONTROLS RISK INDEX			RECOMMENDED CONTROLS
				P	C	R		P	C	R	
1	**Receipt and storage on surface**	a. Stored in adverse conditions	▪ Steel corrodes and unit becomes unusable	D	4	21	▪ Recommended stock turnover on FIFO basis ▪ Appropriate storage conditions recommended by supplier	E	5	25	
2	**Transport underground**	a. RS Bolts damaged in transit	• Damage to unit. Unit unusable	C	5	22	• Proper care during transport	E	5	25	
3	**Transport into stope**	a. Worker drops unit whilst carrying it	▪ Damage to unit	C	5	22		C	5	22	▪ Use mono rope where possible, ▪ Procedure should include a requirement to carry, not throw the unit
		b. Loosely stacked units slide down dip into worker	▪ Minor Injury, damage to unit	C	5	22		C	5	22	▪ Stack correctly in stope storage areas ▪ Training and Supervision
		c. Unit falls off mono rope	▪ Damage to unit	D	3	17	▪ Fastening unit securely	E	5	25	▪ Mine standards for steep areas apply.
		d. Slip and fall whilst carrying RS Bolt	▪ Minor Injury	C	4	18		C	4	18	▪ Good house keeping. ▪ Gate stulls in steep areas. ▪ Mine procedure to prevent rolling rocks etc.
4	**Preparation site for installation**	a. Hammering on RS Bolt	▪ Damage to unit	D	3	17	• Use supplied Dolly	B	2	5	▪ Mine Standard procedures for making safe
		b. Holes drilled too short	▪ Inadequate installation	C	5	22	▪ Supplier training ▪ Supplier recommended procedure	D	5	24	• Mine Standard for hole lengths
		c. Holes drilled at an angle lower than 70 degrees	▪ FOG	B	1	2	▪ Supplier training ▪ Supplier recommended procedure	D	1	7	▪ Mine Standards • Rock Mechanic recommendations
		d. Incorrect length RS Bolt used for conditions	▪ FOG	B	1	2	▪ Supplier training ▪ Supplier recommended procedure	D	1	7	▪ Mine Standards ▪ Rock Mechanic recommendations
5	**Installing the Hydrabolt**	a. RS Bolt protruding from the hole	▪ In adequate support	B	1	2	▪ Supplier training ▪ Correct hole length drilled	D	1	7	▪ Install to full length
		b. Rocks fall during installation or handling	▪ Injury	D	3	17	• Supplier training • Supplier recommended procedure	D	3	17	▪ No workers to work below installation ▪ Remote stressing of the Hydrabolt

	AREA / ACTIVITY /	HAZARD	CONSEQUENCE / EFFECT	PRE-CONTROLS RISK INDEX P	C	R	EXISTING SAFEGUARDS / CONTROLS	POST-CONTROLS RISK INDEX P	C	R	RECOMMENDED CONTROLS
		c. Under size drill hole	▪ Sub standard RS Bolt installation	C	5	22	▪ Supplier training ▪ Supplier recommended procedure	D	5	24	▪ Mine standards and controls.
6	**Pre-stress to required load**	a. Nozzle does not fit onto non-return valve	▪ RS Bolt wont inflate ▪ Injury from falling RS Bolt	D	3	17	▪ Supplier training ▪ Supplier recommended procedure				• Mine standard procedure
		b. Nozzle seal leaks during RS Bolt pressurisation	▪ Operator forced to hold nozzle in position ▪ Danger from falling rock ▪ Danger from pressurised water spray	B	1	2	▪ Supplier training ▪ Mine training ▪ Safety documentation regarding repair of leaks issued by supplier	D	1	7	• Ensure all leaks on installation equipment are repaired immediately • Mine standards to include remote installation
		c. RS Bolt falls out during pre-loading	▪ Injury from falling RS Bolt	D	3	17	▪ Supplier training ▪ Supplier recommended procedure ▪ Remote pre-stressing advised	D	5	24	• Mine standard procedure
		d. RS Bolt is not pre-loaded to the correct pressure Load Indicator not visible.	▪ Sub-standard support ▪ FOG	D	2	7	▪ Supplier training ▪ Supplier recommended procedure				• Training
		e. Bursting of RS Bolt	▪ High-pressure water in eyes.	D	2	12	▪ Correct QA procedures by Supplier	E	2	16	▪ PPE (Eye protection) supplied by mine
		f. Struck by hose	▪ Injury from loose hose	C	4	8	▪ Recommend regular inspections of equipment	D	4	21	▪ Attach hoses securely. ▪ Training
		g. Valve fails after pre-stressing	▪ Loss of load	D	5	24	▪ QA by supplier ▪ Unit pressure tested prior to departure	E	1	11	
		h. Valve damaged by flying rock.	▪ Loss of load	D	5	24	▪ Internal valve unaffected by fly rock.	E	5	25	
		i. RS Bolt fails due to seating on sharp or uneven level	▪ Support loses load, RS Bolt falls out	C	1	4	▪ Design strength is excessive ▪ Extensive tests performed on RS Bolt by CSIR	E	1	11	

Appendix B - Failure Mode and Effect Analysis

	COMPONENT	FAILURE MODE	CONSEQUENCE / EFFECT	SAFEGUARDS / CONTROLS	RECOMMENDED CONTROLS
1	**RS Bolt body**	Failure of weld between valve and body Longitudinal failure	RS Bolt can not be properly pre-stressed	▪ Check material batch chemical analysis certificates ▪ Quality Acceptance testing on all material and components ▪ Low pressure testing of all completed units ▪ High Pressure destruction testing	▪
2	**Valve**	Failure of valve on RS Bolt	Bolt loses approximately 2 tons of existing load. Bolt continues to supply support	▪ Procedures for pre use inspection of valve ▪ Low pressure testing	▪
3	**Face Plate / Washer**	Bent or severed No face plate	Loss of collar support Support element of bolt is not lost	▪ Heavy steel gauge used ▪ Correct packaging	▪