SAFETY IN MINES RESEARCH ADVISORY COMMITTEE

SIMRAC

FINAL REPORT

TITLE: SAFETY DETACHING HOOK SPECIFICATION

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Project No: GAP 536
Date: MAY 1999

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1. INTRODUCTION

1.1 Subject

The subject of this specification is safety detaching hooks for mine shaft conveyances.

According to South African Law[1] it is a legal requirement for all winding systems, where the end of the winding rope is fastened to the drum of the winding engine, to be fitted with a safety detaching hook. The main purposes of a safety detaching hook are to detach the winding rope from the conveyance in the event of an overwind and to support the conveyance in the headgear after such an event.

1 2 Scope

This specification stipulates minimum requirements for the:
- design,
- materials,
- components
- manufacturing,
- testing, and
- quality assurance

of safety detaching hooks in use on mines in the Republic of South Africa.

General guidelines for the installation and operation of safety detaching hooks are attached as Appendix A.

1 3 Purpose

The purpose of this specification is to ensure minimum safety standards and uniformity on all South African Mines.

1 4 Definitions

Act	Any act or amendments to an act promulgated by the Government of South Africa
Approved	Acceptable to and approved in writing by the Chief Inspector of Mines.
Bell	A metal tube section, of which the inner profile resembles the shape of a bell, installed in the headgear structure to activate and arrest a safety detaching hook when the hook is pulled through the tube section in the event of an overwind.
Catch Plate	A plate of a specified thickness, with a round hole of a specified matching diameter, installed in the headgear structure to activate and arrest a safety detaching hook when the hook is pulled through the hole in the plate in the event of an overwind. (sometimes also referred to as the "spectacle plate")
CIM	The Chief Inspector of Mines, or his authorised representative.
CSIR	The South African Council for Scientific and Industrial Research.
Data Book	A book containing a record of identification markings, heat treatments, mechanical, chemical and NDE certification and any other certification requirements of this specification.

Drop back	The vertical distance through which a safety detaching hook will fall onto the catch plate or bell after a full detachment in the catch plate or bell.
Engineer	The Mine Engineer, or his authorised sub-ordinate, legally appointed in terms of an Act to be responsible for shaft equipment.
NDE	Non-Destructive Examination.
OEM	Original Equipment Manufacturer.
Overwind	The event in which a mine shaft conveyance travels upwards past the safe stopping positions in the headgear to the point where the safety detaching hook enters or hits the catch plate or bell.
Professional Engineer	An engineer registered as a 'Professional Engineer' by the Engineering Council of South Africa (ECSA).
QAR	Quality Assurance Representative. An independent inspection agency or person appointed by and approved by the purchaser.
Quality Control Plan (QC Plan)	A document compiled by the Contractor, detailing all major events in the production phase, including but not necessarily limited to inspection requirements, test procedures and acceptance/rejection criteria, sampling plans and equipment to be employed for Quality Control purposes during manufacture and prior to dispatch. Full details of sub-contractor controls shall be included.
'Ra SERIES'	Method of denoting measurements of surface texture as specified in BS1134. It is defined as 'the average deviation from the mean surface' and measured in micrometres (μm).
Regulations	Regulations pertaining to an act or amended act as promulgated by the Government of South Africa.
SAATCA	Southern African Auditor and Training Certification Association.
SABS	South African Bureau of Standards.
Safety Detaching Hook	Any mechanical device that is designed, built or installed with the main purpose of detaching a mine shaft conveyance from the end of the winding rope in the event of an overwind.
SAQCC	South African Qualification and Certification Committee
Statement of Conformance	A document issued and approved by the manufacturer, on completion of the manufacturing or refurbishment of every safety detaching hook, to certify that all the requirements of this specification have been adhered to.
Technical Assessment	An audit report on a manufacturer's systems for the management of product quality, issued by an independent auditor registered with SAATCA.

2. REQUIREMENTS

2.1 Design Requirements

a) General

Safety detaching hooks shall comply with the requirements of all relevant South African Acts and pertaining Regulations.

b) Static Factors of Safety

All safety detaching hooks and load bearing hook components shall have a static factor of safety of at least 10 at the rated safe working load. The static factor of safety on any axially loaded threaded component shall be 15.

c) Fatigue Strength

Safety detaching hooks shall be designed to have an infinite fatigue life, with a minimum fatigue reserve factor (FRF) of 1.3. The method described in the NCB Guideline[2] shall be used to calculate the fatigue reserve factor as follows:

$$FRF = \frac{\text{Allowable stress range at estimated mean stress}}{\text{Actual stress range}}$$

d) Normal Detaching

The hook must be totally reliable in operation. The conveyance must be detached completely from the winding rope when the hook passes through the bell or catch plate. A mechanism to lock the hook in the open position shall be provided, to prevent the hook from falling back through the catch plate or bell after detachment.

e) Accidental Opening

The hook design must only allow detachment when both plates are struck simultaneously, and must incorporate a mechanism to prevent asymmetric plate movement. The hook shall not open or detach when tilted horizontally in a slack rope event or when struck by a falling object (as described in paragraph 2.4 (d) (ii)).

f) Design Drawings and Calculations

Detailed design drawings and calculations shall be compiled for all safety detaching hooks or hook components. Drawings and calculations shall be checked by an (independent) Professional Engineer and be available for inspection by the purchaser or his representative. The grade of material for all components shall be specified on the drawing. Critical dimensions, including those relating the detaching hook to the catch plate or bell and the bottom link in the detached position, shall be shown on the drawings.

g) Modifications

Safety detaching hook components shall be manufactured and marked as complete sets, and shall not be interchanged without written approval from the responsible Engineer. No modification to any existing safety detaching hook is allowed, unless approved by a Professional Engineer.

h) Retrieval Mechanism

The safety detaching hook must have some form of retrieval mechanism to allow the safe removal of the conveyance from the arresting steelwork, after detachment in the headgear. The manufacturer shall provide a retrieval procedure to the purchaser.

2.2 Material Requirements

The manufacturer shall submit certification of the chemical and mechanical properties of the materials used.

a) Safety Detaching Hook Components

Unless otherwise stipulated, all safety detaching hook components shall be manufactured from steel conforming to the following specification:

i) Chemical Composition

The chemical composition of the steel shall comply with the general requirements of BS2772 [3]: Part 2 and the specific requirements for a Group 2 material (150M19 or its equivalent) as detailed in Appendix C of BS 2772:Part 2.

ii) Mechanical Properties

The mechanical properties obtained from test pieces of each billet, bar or plate used in the manufacturing of safety detaching hooks shall comply with the requirements of BS 2772 : Part 2 of 1989.

b) Catch Plates or Bells

Catch plates for safety detaching hooks shall be made of grade 300WA steel to SABS 1431[4] (or the equivalent). Cast detaching bells shall be made of grade A4 normalised carbon steel to BS 3100 [5] (or the equivalent).

2.3 Manufacturing

Prior to commencement of manufacture the manufacturer shall compare the requirements of the contract, drawing, contract specification and this specification. Any discrepancies shall be referred to the responsible Engineer for written direction before manufacture commences.

a) Heat Treatment

Heat treatment shall be conducted prior to final machining and shall conform to the requirements of BS2772. The furnace atmosphere shall be controlled so as to avoid oxidation during heating and soaking. Direct flame on the treated article is prohibited. Component prolongations, matching the largest ruling section, shall be provided for test bars to be machined after heat treatment.

b) Machining

Components supplied to this specification shall be machined from solid sections (billets, bars, castings or plates), or flame cut to the approximate sizes and then machine finished. Welding of components is prohibited. Grease holes in pins are also prohibited. Sufficient material shall be allowed to enable centre drillings in pins to be removed during final machining.

i) Allowance for Machining

A minimum machining allowance of 12 mm shall be made all around for all steel components. Components produced either by flame cutting or forging shall further be proportioned to allow for the heat affected zone to be dressed back to bright metal before final heat treatment and machining commences. When visually inspected after finish machining there shall be no evidence of

forging or flame cutting. Marking and visual inspection during the machining phase shall be detailed on the quality plan and witnessed by the QAR.

ii) Surface Finish

After heat treatment components shall be machined to size in accordance with the dimensional requirements of the relevant drawing and, in accordance with the requirements of the Ra series of BS 1134[6] to a degree of finish as follows:

- General surfaces shall be finish machined to Ra 3.2µm or better.
- Pins, bores and radii shall be finish machined to Ra 1.6µm or better.

iii) Tolerances

The following general dimensional tolerances will be allowed:

- The allowable tolerance on the centre pin diameter shall be -0.07/-0.04mm.
- For other pins, the tolerance on the pin diameters shall be ‘h9’ to BS EN 20286-2[7].
- The tolerance on the centre pin hole diameter shall be +0.00/+0.03mm.
- The tolerance for other pin holes / slots shall be 'D10' (to BS EN 20286-2) plus 0.5mm.
- The allowable tolerance on all other dimensions shall be -0.5/+0.5mm.

c) Identification Marking

A suitable non-stressed area of each component shall be stamped with 5mm high character stamps. The following shall be stamped on each component:

- A unique ID number
- The relevant set number
- A material cast number
- An NDE stamp.

The following shall be stamped at only one visible, non-stressed area on the assembled safety detaching hook:

- The safe working load of the hook
- The proof load test number
- The manufacturer's name or logo
- The manufacturer's job number
- The manufactured date (year only).

2.4 Tests and Inspections

Tests and inspections will be carried out on all safety detaching hooks and hook components, and all the results of such tests and inspections will be properly recorded and filed in a data book (defined in paragraph 2.5 (f)).

a) Material Testing

Safety detaching hook materials shall conform to the requirements of BS 2772[3] Part 2 (unless otherwise specified) and test pieces shall also be prepared and tested in accordance with Appendix A of BS 2772.

- Tensile tests shall be in accordance with the requirements of SABS ISO 6892[8].
- Charpy V-Notch impact tests shall conform to the requirements of SABS ISO148[9]

The testing of materials other than those to BS 2772 shall be in accordance with the requirements of the relevant specification (e.g. BS 3100, SABS 1431).

b) Dimensional Checks

After finish machining, all safety detaching hook component dimensions will be checked against that on the design drawing. If a component does not satisfy the tolerance criteria listed in paragraph 2.3 (b) (iii), it shall be re-machined if possible. Otherwise, the component must be discarded or a concession request must be submitted to the Engineer.

c) Non-destructive Examinations

Non-destructive examinations shall be in accordance with the requirements of BS 6072[10] and BS EN 583-3[11]. All the required non-destructive examinations will be conducted by independent technicians qualified in the relevant categories to at least Level 2 of the SAQCC, or the equivalent. Only calibrated equipment with valid calibration certificates will be used for NDE. All examinations relevant to the quality control plan shall be witnessed by the QAR. Final NDE shall be conducted after proof loading.

Note that it may be to the manufacturer's advantage to also conduct NDE at the following stages:

- Before forming
- After forming and rough machining
- After heat treatment
- After final surface machining

i) Magnetic Particle Tests

Magnetic particle inspections (MPI) will be conducted individually on all new steel components of safety detaching hooks. MPI shall take place after final machining, but before assembly. All accessible surfaces shall be magnetically tested. Prior to testing, the component surfaces shall be cleaned with a cleaning solvent that is not oil-based. Sandblasting of components is not permitted. MPI shall be conducted in good lighting conditions. Each surface shall be tested twice, with the direction of the flux rotated through 90° for the second test. A suitable magnetic flux density shall be selected according to the recommendations of the test equipment supplier. A safety detaching hook component shall be rejected if any defect is identified by the MPI.

ii) Ultrasonic Tests

After final machining, all safety detaching hook components shall be tested ultrasonically. The ultrasonic transducer (probe) will be used to scan 100% of the component surface, i.e. to test each component all over and from both sides. A twin crystal, 4MHz transducer and a proper coupling medium (SAE

90 gear oil recommended) shall be used. The provided calibration block will be used to check the equipment calibration before every test. The test technician shall be familiar with the 'near fields' and 'dead zones' of the transducer used and shall avoid their inclusion in the test results. A component shall be rejected if, when scanned over the full surface, there is any defect causing in excess of 20% full scale reflection at the gain required for full scale end reflection.

d) Type Tests

Safety detaching hooks shall be subjected to type tests as described in the following paragraphs:

i) Functional Type Tests

A functional type test shall be conducted on a prototype of each size of new, modified or reconditioned safety detaching hook. Assembled together with all the attachments that connect it to the rope, the prototype hook shall operate properly in all respects when pulled vertically through a matching dummy spectacle plate or bell. For this test, the hook shall carry no suspended load and any components rendering resistance to opening (e.g. shear pins or set screws) shall be included. The load required to detach the hook completely under these conditions will be measured and shall not exceed 25% of the maximum rated safe working load of the hook. This test shall be conducted by the manufacturer or workshop owner and witnessed by the QAR.

ii) Vertical Single-sided Impact Tests

Prototypes of all sizes of safety detaching hook designs or hooks with new types of modifications shall be tested for resistance to accidental opening by single sided impact loads. The hooks shall be tested at a facility approved by the CIM. Each vertical single-sided impact test shall be certified by the test facility.

The prescribed test method is as follows:

A guided impactor shall be dropped vertically onto one side of the hook opening mechanism, e.g. onto a scissor plate lug. . The safety detaching hook must be tensioned to 50% of its rated safe working load with a hydraulic tensioning system The impactor must subject the safety detaching hook to an impact energy of 150 kJ minimum. A high speed digital imaging system, capable of recording at least 2000 full frames per second, shall be used to record video images of the safety detaching hook during the test. A high speed data logger, capable of sampling rates up to 2kHz, shall be used to record load signals during the test.

The safety detaching hook design shall be rejected if the hook opened either fully or partially during the test. The hook shall be regarded as 'fully open' when the hook has released the pin. A four-plate detaching hook shall be regarded as 'partially open' if the hook tips of the scissor plates have passed each other. A three-plate detaching hook will be regarded as 'partially open' if the vertical centerline of any of the top or bottom pins has moved past the sharp-cornered edge of the matching slot in the outer plates.

A description of a possible test facility is attached as Appendix B. A schematic diagram of the proposed bottom and top sections of a possible test tower is shown in Figure 1 on page 12.

e) Operational Tests

Safety detaching hooks shall be subjected to operational tests as described in the following paragraphs:

i) Functional Tests

A functional test shall be conducted on each new, modified or reconditioned safety detaching hook. Assembled together with all the attachments that connect it to the rope, each hook shall operate properly in all respects when pulled vertically through a matching dummy spectacle plate or bell. For this test, the hook shall carry no suspended load and any components rendering resistance to opening (e.g. shear pins or set screws) shall be excluded. This test shall be conducted by the manufacturer or workshop owner and witnessed by the QAR.

ii) Proof Load Tests

Every new or modified safety detaching hook shall be statically tested to at least 2.5 times its rated safe working load. The tests shall be witnessed by the manufacturer, the QAR or the purchaser's QAR, After the proof load test, the safety detaching hook shall be disassembled and a dimensional check and non-destructive examination (Magnetic Particle Inspection or Dye Penetrant Inspection) conducted on all individual components. Any component that shows signs of distortion or a defect will be discarded and replaced at the manufacturer's cost.

f) Routine Inspections

The following routine inspections shall be conducted on all operational or installed safety detaching hooks:

i) Inspection on Commissioning

All installed safety detaching hooks will be inspected and tested on commissioning, as required by the relevant Act[1].

ii) Daily Inspections

All safety detaching hooks in operation will be inspected daily by a responsible person appointed in terms of the relevant Act[1].

iii) Six Monthly Inspections and Tests

Safety detaching hooks should be removed at six monthly intervals and the following inspections or tests should then be carried out on all components:

- A dimensional check.
- A magnetic particle inspection (MPI) as per paragraph 2.4 (c) (i).
- An ultrasonic test as per paragraph 2.4 (c) (ii).

2.5 Quality Assurance

Proper quality control shall be exercised during all stages of manufacturing, and shall be the responsibility of the manufacturer. The manufacturer shall comply with the requirements of SABS ISO 9001[12] , as amplified in the guidance document SABS ISO 9004-1[13].

a) Traceability

Hard stamp traceability shall be maintained throughout production on all safety detaching hook components. The stamping shall be visible after final assembly. Hard

stamping of safety detaching hook components must be applied in areas of low stress, which must be detailed on the relevant drawings.

b) Design Verification
A design verification conducted by a Professional Engineer shall be provided for safety detaching hooks of a unique proprietary design.

c) Quality Control Plans
The manufacturer shall submit with his tender draft manufacturing quality control plans (QC plans) for each safety detaching hook. Each draft QC Plan shall identify all quality related activities and shall detail verifications, tests and inspections for each activity. If a tender has been successful, the manufacturer shall identify all planned work on a final QC Plan and shall not commence work until the document has been reviewed and approved by the QAR.

d) Quality Surveillance
The Engineer or the nominated QAR shall be entitled access at all reasonable times to assess the products, workmanship and quality system documentation of the manufacture. Unless otherwise agreed, the manufacturer shall provide free of charge such assistance, materials, electricity, fuel, stores, facilities, apparatus, lifting equipment and instruments necessary to carry out efficiently all workshop tests required by this specification.

e) Certificate of Conformance
The manufacturer shall, before the dispatch of any safety detaching hook, issue a certificate of conformance. Certificates of conformance shall be countersigned and stamped by the QAR. Further work on any component of the safety detaching hook shall not be performed after the issue of a certificate of conformance.

f) Data Books
During the manufacturing process, the manufacturer shall progressively compile a data book for each safety detaching hook supplied in accordance with this specification. The manufacturer will keep the original data book filed for an unlimited time, and will supply two copies to the purchaser. The data book shall contain the following information or documents:

- The original order from the purchaser or responsible Engineer
- The manufacturers job number
- Material test certificates (chemical composition and mechanical properties)
- Heat treatment certificates
- An identification sheet, including all component numbers
- NDE certificates (magnetic particle tests, ultrasonic tests, etc.)
- Proof load test certificates
- The quality control (QC) plan
- The manufacturer's Statement of Conformance.

g) Discard Criteria
In addition to failing the requirements of any South African Act, a safety detaching hook or hook component shall also be discarded or refurbished if.

- it does not meet the manufacturer's in-service dimensional specifications,
- it fails any non-destructive examination,
- it has deformed permanently,
- it has corroded to such an extent that the surface finish is no longer acceptable,

- it has been involved in a high speed overwind.

3. FIGURES

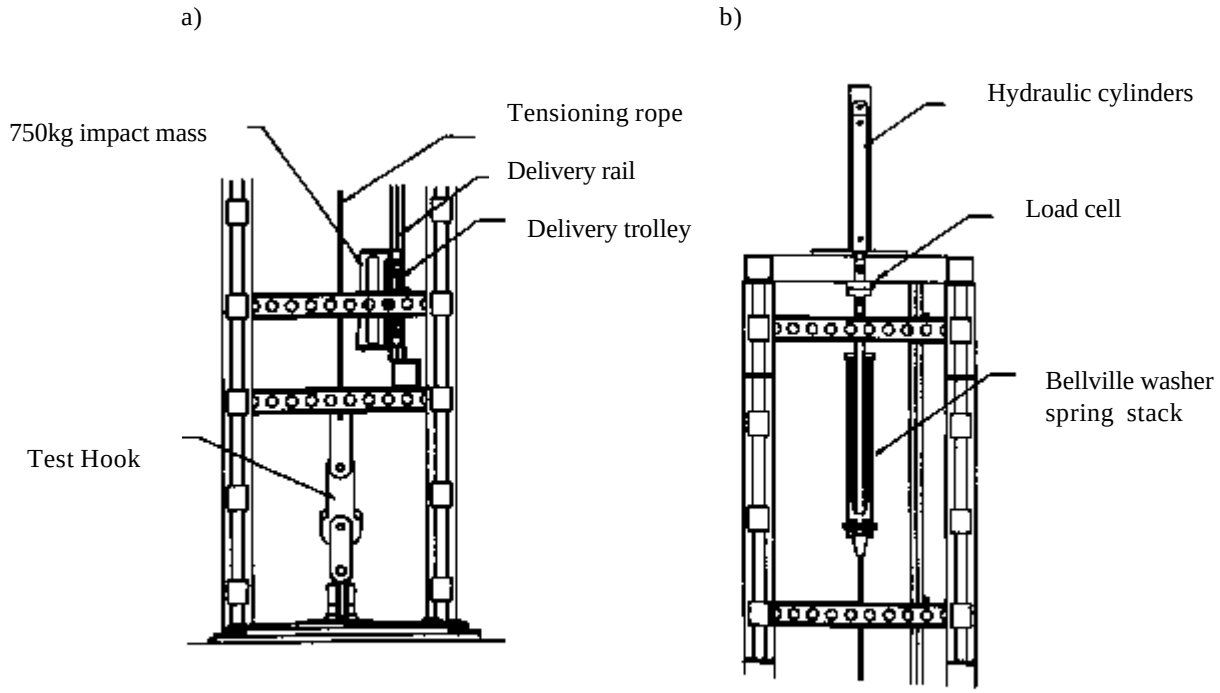

Figure 1: Schematic of detaching hook test rig showing
a) test area with hook in place and 750 kg mass on trolley, and
b) hook tensioning system at top of rig

4. APPENDICES

APPENDIX A GUIDELINES FOR THE INSTALLATION AND OPERATION OF SAFETY DETACHING HOOKS

a) Orientation
The safety detaching hook shall be installed such that its centre line matches that of the catch plate or bell. The alignment of the safety detaching hook to the catch plate or bell should be checked weekly or when any modifications are done that could affect the alignment. Any reason for the winding rope rubbing against the catch plate or bell will be investigated and corrected immediately.

b) Slack Rope Event
Chaseblocks shall be used between the conveyance and safety detaching hook to prevent the scissor plate lugs from touching the top of the conveyance in the event of the hook tilting under a slack rope condition.

c) Detachment Test
On commissioning, the conveyance and winding rope will be supported in the headgear and the safety detaching hook will be pulled through the catch plate or bell until full detachment of the winding rope occurs. (The copper shear pin shall be removed during this test.) Any irregularities in the detaching process will be noted and the necessary steps will be taken to rectify that before the winder is commissioned.

d) Drop-back
During the detachment test, the drop back distance of the detached conveyance will be measured and recorded. The measured drop back distance shall not exceed the value shown in the supplier's catalogue.

e) Modifications
No site modifications to any component of a safety detaching hook will be permitted, unless approved by a Professional Engineer.

f) Corrosion Protection
Installed safety detaching hooks should be protected against corrosion by applying grease or another suitable coating to all surfaces. Metallic based grease is not permitted. No painting, galvanizing, electroplating or other permanent coating is permitted. Excessive grease should not be applied to the locking pin or slots in which the locking pin drops, because this could impede the proper functioning of the locking pin in the event of a detachment.

g) End Attachments
Ninety degree (90 °) chaseblocks, which offers flexibility in both directions, are preferred as end connections to both ends of safety detaching hooks. Link plates or shackles may also be used.

h) Traceability
Traceability of all components must be maintained throughout the life of the hook.

APPENDIX B: POSSIBLE TEST FACILITY FOR VERTICAL SINGLESIDED IMPACT TESTS

The test facility for vertical single-sided impact tests could be set up as follows:

The safety detaching hook will be mounted vertically in a test tower, at the bottom end of a 20 to 40m length of winding rope. The steel anchor and attachments used must be representative of the worst case service configuration. The anchor arrangement will allow horizontal adjustment of the hook position in two perpendicular directions for accurate targeting of the impact point on the scissor plate lug.

A tensioning system, capable of applying the maximum rated safe working load of the tested hook will be mounted at the top of the test rig. This will comprise of a hydraulic ram connected via a load cell to one end of a Belville washer spring stack. The bottom end of the spring stack will be connected to the length of winding rope. The combination of the winding rope and spring stack shall be designed to provide a reasonable level of elasticity in the tensioning system (250mm total extension at 200kN recommended).

A large impactor shall be dropped vertically onto one side of the hook opening mechanism, e.g. onto a scissor plate lug. The impactor mass and drop height shall be selected to deliver a minimum kinetic energy value of 150 kJ at impact. The impactor shall incorporate a strike ring, which can be rotated between impacts (and eventually replaced) to provide a fresh strike surface for each test. The edge of the strike ring shall be bevelled at 25° from the horizontal, to reduce plastic deformation of the contact surfaces. The upper body of the impactor shall be machined away on the side of the hook, to prevent the shoulder of the recoiling scissor plate from hitting the impactor after the initial impact.

The falling impactor will be attached to a guide trolley by means of a bolt in a nylon bush. The guide trolley will run on a rail and, by changing direction on a spring buffer just above the impact point, will release the impactor by shearing the nylon bush.

A high speed digital imaging system, capable of recording at least 2000 full frames per second, shall be used to record video images of the safety detaching hook during the test. A high speed data 1ogger, capable of sampling rates up to 2kHz, will be used to record the load cell signal during the test.

The single sided impact test could be conducted as follows:

The impactor will be attached to a hoist rope, using an electrically operated release mechanism. The impactor will be lifted, attached to the guide trolley and raised to the required dropping height. The safety detaching hook will be installed in the test tower and positioned accurately by using a plumb line from the impactor edge. The safety detaching hook must be tensioned to 50% of its rated safe working load with the hydraulic tensioning system. With the digital imaging system and load cell data logger running, the release mechanism will be activated to release the impactor. When the guide trolley hits the spring buffer and reverses direction, the nylon bush will shear and release the impactor. The impactor will continue in free fall and strike the safety detaching hook at the selected impact point on the scissor plate lug. After the impact test, the hook will be inspected for any signs of opening and the recorded digital images and load cell readings of the test will be analysed. To quantify the hook response to the impact, and gain some better understanding of the hook behaviour, the amount of energy absorbed by the safety detaching hook could be calculated from the video record.

APPENDIX C: RECORD OF AMENDMENTS

No amendments to date.

5. REFERENCES

Unless otherwise specified, relevant extracts from the latest issues of the following documents shall be deemed to form part of this specification:

1 South African Mine Health and Safety Act, Act 29 of 1996 (as amended), and Regulations.

2 British National Coal Board's Design Guide for Cage Suspension Gear: 1983.

3 BS 2772 - Colliery haulage and winding equipment, including Part 2:1989 - Specification for wrought steel.

4 SABS 1431:1987 - Weldable structural steels.

5 BS 3100:1991 - Specification for steel castings for general engineering purposes. (This specification replaces BS592C.)

6 BS 1134 - Assessment of surface texture, including
Part 1: 1988 - Methods and instrumentation, and
Part 2 : 1990 - Guidance and general information.

7 BS EN 20286-2 - Tables of standard tolerance grades and limit deviations for holes and shafts. (This is the renumbered version of BS 4500 : Part 1 : Section 1.2.)

8 SABS ISO 6892 : 1984 - Tensile testing of metallic materials.

9 SABS ISO 148 : 1983 - Charpy V-notch impact testing of steels.

10 BS 6072 : 1981 (1986) - Method for magnetic particle flaw detection..

11. BS EN 583-3 : 1997 - Transmission technique for non-destructive ultrasonic examination.

12. SABS ISO 9001:1994 - Quality systems - Model for quality assurance in design, development, production, installation and servicing.

13 SABS ISO 9004-1:1994 - Quality management and quality system elements, Part 1 - Guidelines.