Safety in Mines Research Advisory Committee

Final Report

Develop Discard Criteria for Non-spin Wire Ropes

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Executive Summary

The initial project objective was to correlate the level of internal broken wire indications, obtained using a magnetic rope test instrument, with rope strength loss and then to propose a given indication level at which non-spin ropes are to be discarded. No experimental data became available during the course of the project and, therefore, relatively conservative discard were recommended, based on current practice and on discussions with rope inspectors and other parties concerned with rope safety.

Two appendices to the report present recommended changes to the discard criteria and other changes to the code of practice for rope condition assessment (SABS0293) respectively. Where appropriate, background information is presented to facilitate a decision on how to implement these changes.

A third appendix presents responses obtained when the draft version of this report was circulated.

Acknowledgements

I would like to express my gratitude to the following interviewees for their contributions towards the rope discard criteria proposed in this document:

- Mr S Mostert and his colleagues at Anglo Field Services
- Mr M Borello and his colleagues at Haggie
- Mr D Petersen representing TAS
- Messrs P Musgrove, C Pagani and G Bezuidenhout of Alstom

I would like to thank CSIR Miningtek for allowing the use of data from their rope test records.

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Glossary of abbreviations, symbols and terms

Abbreviations

MRTI - Magnetic rope test instrument

Symbols

Symbols are only used in equations in the appendices. They are defined there.

Terms

Broken wires

The term is used for wires that are broken, cracked or split. Often a differentiation has to be made whether the *number of broken wires* should mean the number of wires with the mentioned defects or the number of defects, in which case the term *wire breaks* is more appropriate.

Discard factor

The sum of the ratios between each defect level and the allowable level for that defect. A discard factor of one or more requires that a rope be discarded.

Non-spin ropes

Multilayer ropes in which wire layers in the strands are laid up in opposite directions to produce opposite torque values when the rope is subjected to tension so that the torque generated in the rope is minimised and its end therefore hardly rotates when it is freely suspended.

1 Introduction

A considerable amount of research has been done in preparation for the rope inspection techniques and discard criteria in SABS 0293 1996 "Condition assessment of steel wire rope on mine winders". The work has proved to be very successful in the application of SABS 0293 on triangular strand ropes. As far as *non-spin ropes* are concerned, however, the procedures for rope inspection cannot be applied successfully. A different approach was therefore required.

The problem with inspecting non-spin ropes is the fact that wire breaks often occur in the inner layers. Dohm (1999) reported that no magnetic inspection technique has yet proven successful in identifying and counting the number of internal wire breaks and SABS 0293 only specifies a maximum allowable number of visible wire breaks. The discard criteria can thus not be applied.

The approach that SABS 0293 prescribes for discarding corroded ropes is to determine the correlation between the metallic area trace produced with a specific magnetic rope test instrument (MRTI) and the reduction in rope strength due to corrosion. The discard criterion for corrosion is then based on this correlation.

A similar approach was proposed for internal broken wires in non-spin ropes. The project objective was to correlate the level of broken wire indications with rope strength loss and then to propose a given indication level at which non-spin ropes are to be discarded.

2 Literature study

Hamelin et al (2000) state that the use of a discard criterion based on the loss of breaking strength appears unsatisfactory. The loss of breaking strength they refer to, however, is based on metallic area information obtained from MRTIs and not on wire break indications. They report that a rope remains at full strength until severe fatigue and wire breaking starts shortly before complete failure. They then propose a signal processing technique that computes the Rope Damage Index based on digitised signals obtained from a MRTI.

Winter et al (2000) report on an instrument described by Nussbaum (2000) used in a case study. In this study the instrument counted 87% of the wire breaks, compared with 51% obtained with a *conventional* instrument and 21% counted during a visual inspection.

These articles all appeared after GAP503 was produced. They are very relevant to the subject but, unfortunately, neither present a correlation between the MRTI indication and the remaining rope strength. The discard criteria in SABS 0293 are based on such correlations, mainly because of this ensures the rope safety factor.

Kuun (1993) has provided the only relevant information to this project. Three case studies are presented, together with MRTI indications, the results of visual inspections and destructive tests.

Wainwright (1996) recommends that “The draft code *(precursor to SABS 0293)* should not be used for assessing non-spin ropes. Further work is required in interpreting electro-magnetic test traces of these ropes and combining them with revised requirements for non-spin ropes. Requirements for Koepe ropes should be different from those for non-spin ropes operating on drum winders”.

SABS 0293 itself has a note that states: “Detailed discard criteria for the various constructions of multi strand non spin ropes are currently being developed at the CSIR Cottesloe”. This is most likely a reference to the work done under SIMRAC projects GAP 324 and GAP 439.

Hecker et al (1997) proposed that a non-spin rope with internal broken wires should be discarded when the loss in wire area is 6% of the rope area. This proposal was based on a limited number of tests on a fishback non-spin rope.

3 Research methodology

The original project proposal was based on the assumption that the problem was widespread and that information would readily be available. It was proposed to accumulate broken wire traces obtained from MRTIs and to do destructive tests on the corresponding rope sections after the ropes were discarded. With a correlation obtained between the broken wire indication and rope strength, a discard criterion could then be proposed.

Provision was initially made to obtain twenty samples from discarded ropes, together with the MRTI trace taken before they were discarded, and then to attempt to correlate the breaking strength of the samples with some interpretation method of the MRTI trace.

All rope inspection organisations in South Africa were requested to provide instrument traces and to assist in obtaining tensile test specimens from discarded ropes. Two years into the project (which was planned to be completed within nine months), not a single sample was obtained. An ad-hoc project meeting was held on 12 November 2002 to discuss a new approach towards the project. It was agreed that the following methodology is adopted:

- Since no specimens had been obtained and it was reported that no non-spin ropes had been discarded because of internal broken wires, the occurrence of internal broken wires may be an infrequent event. The “size of the problem” was to be investigated.
- If the “size of the problem” was small, it would suffice to specify a conservative discard criterion.
- Other discard criteria in SABS 0293 were to be revisited and changes proposed.

A revised project was proposed according to the above and the proposal was submitted on 7 January 2003.

3.1 Envisaged technical approach

With only the data available that was presented by Kuun (1993), a method to arrive at a discard criterion was based on the results of three tensile tests. Details of the derivation of the discard criterion are presented in Appendix 1.

This criterion, chosen at the outset of the project, looked promising and verification with test data was anticipated.

3.2 Final approach followed

Since no test samples became available, the project was changed to study the extent to which internal broken wires in non spin ropes contribute to the total number of reasons for discarding ropes. This was done in the following steps:

- Ascertain the number of non-spin ropes operating in South Africa and the installations where they operate
- Interview the rope inspectors responsible for the installations determined
- Obtain the reasons for discarding ropes on each of these installations
- Decide on a practicable discard criterion for non spin ropes with internal broken wires

4 Discussion of results

4.1 Processing of MRTI signals

The rope damage index calculations discussed by Hamelin et al (2000) provide a pointer towards extracting information from MRTI signals. Unfortunately the experimental data presented is only from a single laboratory fatigue test and this provides no pointers towards a discard criterion that will ensure that a rope with internal defects will be removed when its strength has reduced by 10%.

The simple calculations shown in Appendix 1 have shown promising results. This may, however, only be due to the unacceptably small amount of information analysed.

4.2 Discarding of non-spin ropes

Figure 1 illustrates the distribution of various rope constructions operating on licensed winders in South Africa. Approximately 10% are non-spin ropes.

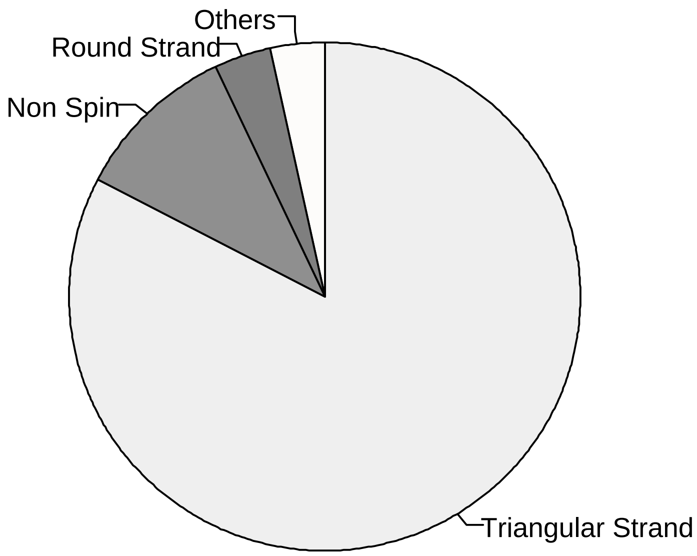


Figure 1 Distribution of installed rope constructions

When interviewing the rope inspectors responsible for these installations, it was found that several winders were no longer in operation. Mine closures and the end of sinking operations were stated as the reasons.

Of those winders still in operation, the main reason for discarding the ropes was corrosion. It was also reported that MRTI signals were previously interpreted as internal wire breaks while they were actually due to nicking and pitting resulting from internal corroded wires.

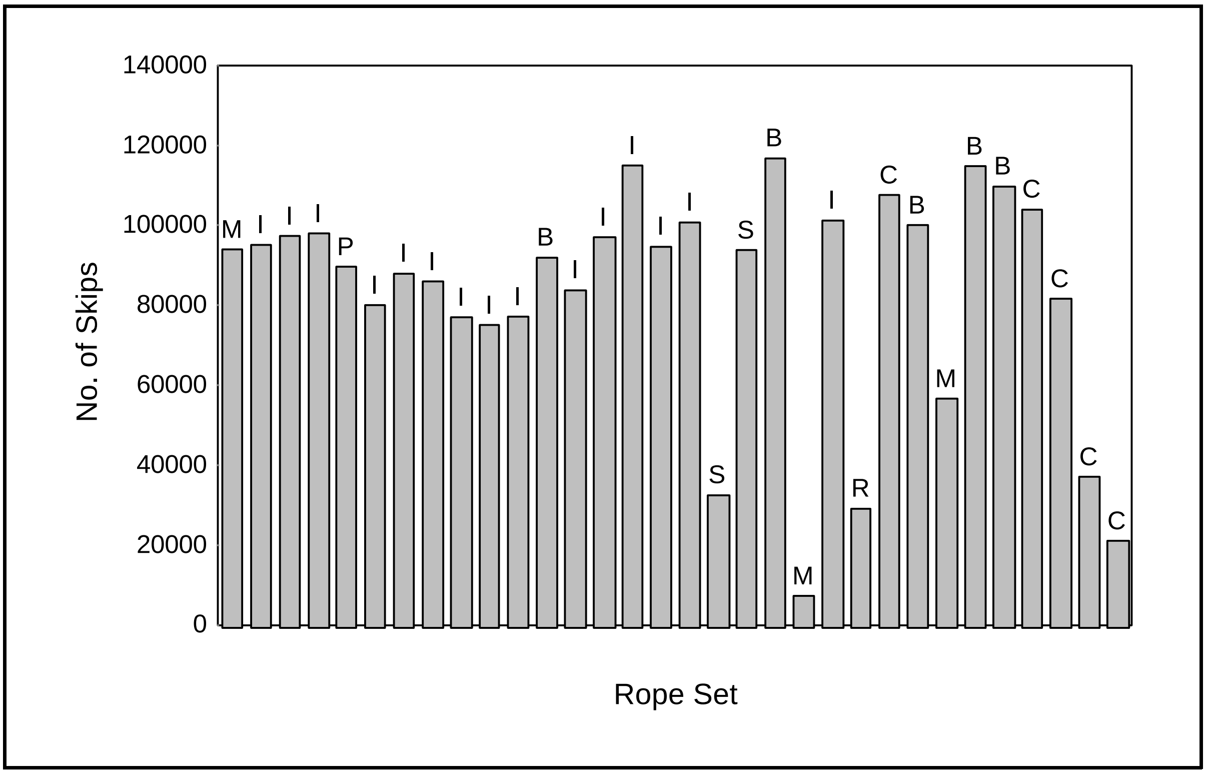


Figure 2 Successive rope lives achieved on a Koepe winder

Reasons for discard:

M	mechanical damage
I	internal broken wires
P	policy
B	external broken wires
S	single anomaly
R	rope failure
C	corrosion

Figure 2 shows an example of a winder where previous rope sets were discarded due to internal broken wires. Lately, however, corrosion is the main reason for discard. Another factor stated for the change in deterioration mode is the fact that the winder is less busy. It hoists fewer skips per month. The rope lives therefore increase in terms of the time that they are installed. This provides a greater opportunity for the ropes to corrode, resulting in reduced lives in terms of skips hoisted.

4.3 Discard criteria for non-spin ropes

When confronted with the request for a discard criterion for non-spin ropes with internal broken wires, most interviewees were at a loss for a suggestion. The following remarks and suggestions were, however, made:

- A rope must be discarded if there is any indication of a failed core wire.
- When internal wire breaks are detected, more than one break per lay length is reason for discard.
- Internal wire breaks, even cracked wires, can be detected by increasing the gain of the local fault channel. This, however, needs experience.
- The project should continue as planned until discarded non-spin rope samples with internal broken wires become available.
- The current discard criteria need to be tightened. It was reported that a rope was discarded with a discard factor of less than one. The mine then submitted a sample of the rope for a tensile test and the loss in breaking strength was 14%. (This suggestion is irrelevant as there are no current discard criteria and the rope inspector could therefore not have calculated a discard factor).

4.4 Other discard criteria in SABS 0293

The suggestions that were made regarding the code of practice are listed in appendices 2 and 3. Since these do not form part of the main objective of the project, they have been included in the appendices rather than in the main section of the report. This does not, however, imply that they are less important. Where appropriate, supplementary information is provided to assist in deciding on a revision of the document.

5 Conclusions and recommendations

Section 4.2 has shown that the "size of the problem" is small enough to recommend a conservative discard criterion. Recent developments indicate that single layer ropes will be used on deep shafts and that the size will therefore not increase due to new installations.

Based on the suggestions made regarding the discard of multilayer ropes with internal wire breaks, the discard criteria should be formulated according to the items listed in section 4.3, except the last one.

A method of combining local fault and metallic area indications, such as that described by Hamelin et al (2000), could provide a basis for the interpretation of MRTI information and warrants further investigation.

Previous SIMRAC projects on rope discard criteria all led recommendations that further tests are done. Each subsequent project, including this one, again suffered from a lack of discarded rope samples. It is therefore proposed to develop a strategy for obtaining samples of discarded ropes. The following items should be addressed:

- Incentives for mines to make samples available.
- Rope constructions and types of defects required in the samples.
- Background information (e.g. rope life history) required with the samples.
- A methodology that ensures that the best information is obtained from each sample.

References

Dohm, M. 1999. An evaluation of international and local magnetic rope testing instrument defect detection capabilities and resolution, particularly in respect of low rotation, multi-layer rope constructions. *SIMRAC Report GAP 503*

Hamelin, M., Hofmeister, L. and Leung, K. 2000. Using the Rope Damage Index to predict the endurance of mine-shaft wire ropes in Canada. *OIPEEC Bulletin* 80

Hecker, G.F.K., van Zyl, M.N. Wainwright, E.J., Goosen, P. and Heydenrych, C. 1998. Deterioration and discard of mine winder ropes. *SIMRAC Report GAP 324*

Hecker, G.F.K., Wainwright, E.J. and Heydenrych, C. 1998. Deterioration of mine winder ropes. *SIMRAC Report GAP 439*

Kuun, T.C. 1993. Low rotation winding ropes for long lift drum winders. (Document presumably prepared for use within Anglo American Corporation - copy supplied by Mr. M Dohm.)

Kuun, T.C. 1996. Practical aspects of rope inspection. *SIMRAC Report GAP 054 Vol.5*

Nussbaum, J.-M. 2000. Detection of broken wires using a high resolution test method. *OIPEEC Bulletin* 80

Wainwright, E.J. 1996. Discussion of results of tests on discarded ropes in terms of the draft code of practice on rope condition assessment. *SIMRAC Report GAP 054 Vol.4*

Winter, S., Briem, U. and Nussbaum, J.-M. 2000. High resolution magnetic wire rope test - case study. *OIPEEC Bulletin* 80

Appendix 1: Analysis of broken wire traces

Figure 3 shows an example of the traces obtained with a magnetic rope test instrument. The upper trace shows wire break indications while the lower trace shows steel area loss. The markers above the upper trace indicate 1 m intervals along the rope.

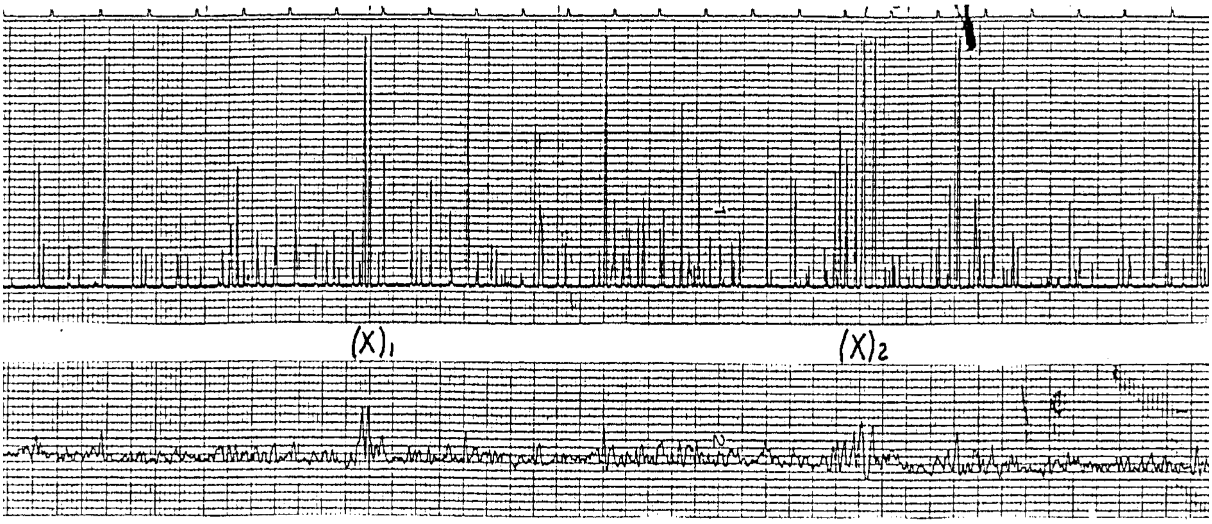


Figure 3 Example of traces produced by a magnetic test instrument

In order to be able to process the information in Figure 3, the image was digitised (scanned) and the height of the peaks in the broken wire (upper) trace was derived from the scan. The vertical axis was initially just calibrated in length units while the horizontal axis was calibrated from the markers at the top of the broken wire trace in Figure 3 which represent 1 m intervals along the rope. Figure 4 shows the peaks of the trace in Figure 3.

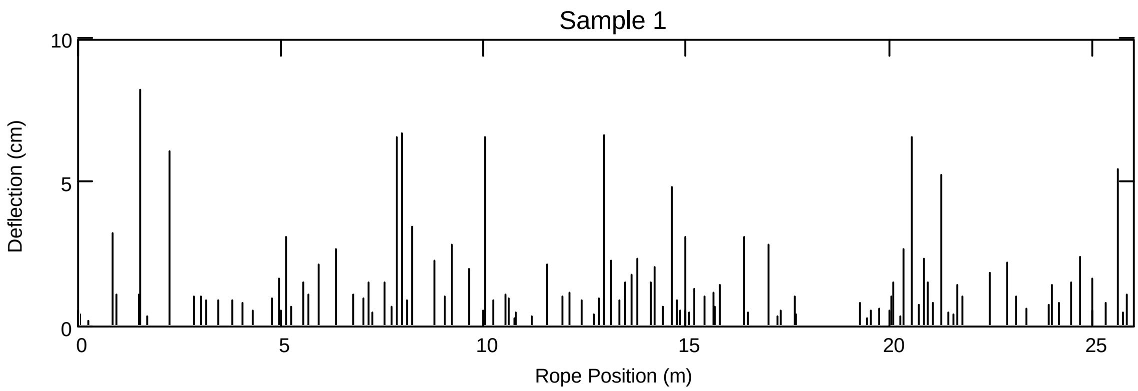


Figure 4 Graph of peaks obtained from Figure 3

It was initially assumed that the traces were calibrated as prescribed by Kuun (1996:19), namely that the instrument sensitivity was adjusted to give 50% full scale deflection for an equivalent broken outer wire of the rope. Later investigations, however, showed that this assumption could not be confirmed. The method, therefore, could not be used to derive a discard criterion. It is only repeated here because it formed part of the project and was used to give direction to a method of analysing the expected data.

Having obtained a numerical value for the local fault indications, several methods of interpreting the indications were tested. The method that gave the best results was a simple summation of the signal levels over a length of the rope.

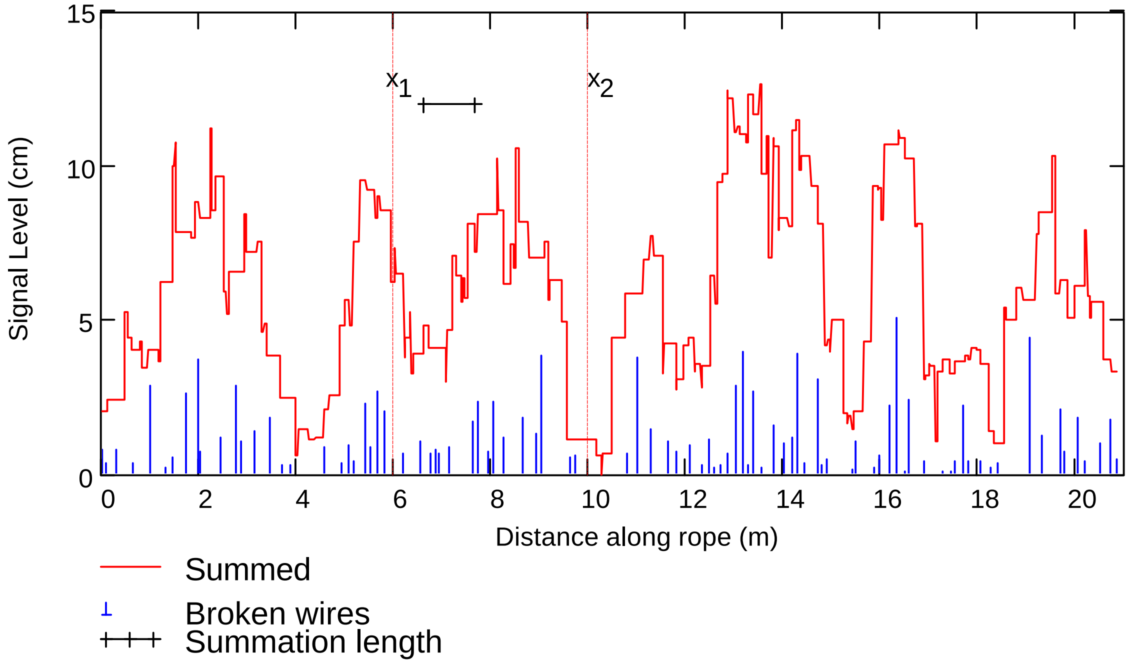


Figure 5 Signal processing example

Figure 5 shows a graph that was produced by adding the local fault indications over a length of five inner rope lay lengths. The vertical lines marked x_1 and x_2 indicate where the rope was cut to obtain a tensile test specimen. This process was repeated for the three rope lengths from which test specimens were cut and for three different summation lengths. The results of the various calculation methods for the three samples are shown in Figure 6.

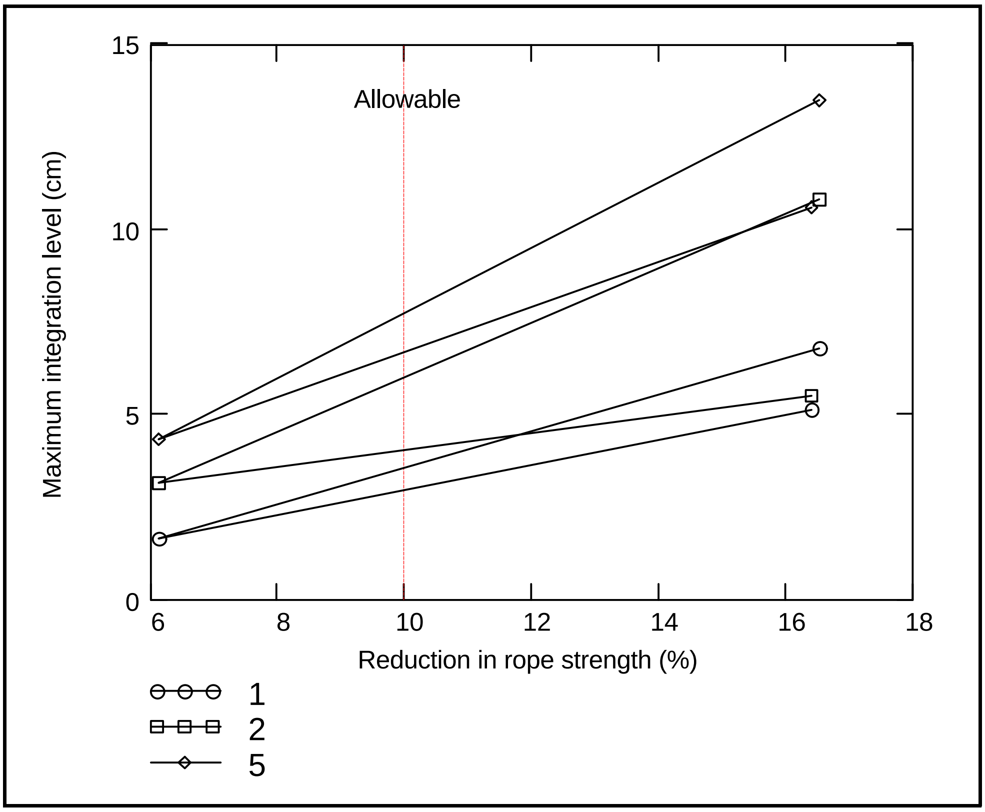


Figure 6 Correlation between rope strength and processed local fault signal

The correlation coefficients for the three methods are shown in the table below:

Summation Interval	Correlation coefficient
One inner rope lay length	0.95
Two inner rope lay lengths	0.74
Five inner rope lay lengths	0.95

Having only three samples, the summation interval could probably have been varied until a correlation coefficient of very close to one was obtained. This, however, would have been meaningless statistical manipulation: Such a small statistical sample can be forced to represent virtually anything.

Appendix 2: Proposed changes to discard criteria in SABS 0293

This appendix can only be read in conjunction with SABS 0293. The sections that follow contain suggestions made during the interviews with rope inspectors and other concerned parties. Parentheses indicate suggested wording to be used.

5.5

"Broken wires"

This section needs a division into "Visible broken wires" and "Internal broken wires" as MRTI wire break indications are not covered:

"5.5.1 Internal broken wires

Any indication of internal broken wires shall be reason for discard."

or

"5.5.1 Internal broken wires

a) Any indication of broken core wires shall be reason for discard.*

b) Any indication of more than one internal wire break in one actual lay length shall be reason for discard."

* Kuun (1996: 25) states that

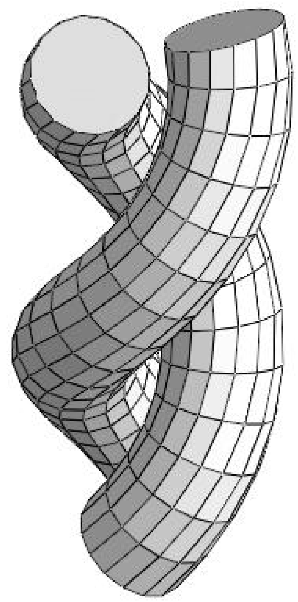
"Any indication in core failure in non spin ropes is justification for immediate discard of the rope"

5.5.1 c)

There should be a differentiation between constructions to take into account by how much the outer wires contribute towards the total rope area.

To bring the 40% into perspective, the following should be considered:

Consider the simplest case of two wires coiled around one another: When this construction is loaded in tension, each wire ensures that the other maintains its shape due to the radial force acting along the line of contact between the wires. When one of these wires breaks, the other is not able to keep its shape any longer and it becomes a single helix with an axial stiffness that is much lower than 50% of the stiffness of the two wires combined.



If these two wires formed a strand in a rope undergoing a tensile test, the failure of one wire would reduce the stiffness of the strand to such an extent that it would no longer contribute to the axial force applied to the rope, i.e. it would be as good as a strand that was completely broken.

This phenomenon was observed when tensile tests were conducted on non-spin ropes with broken outer wires (GAP439): When one or two of the eight outer wires were broken, the loss in rope strength was significant.

5.5.1 Note

Remove!

5.6.1

It is common practice to use a graph showing a plot of indicated area loss plotted against strength loss. The area loss corresponding to the allowable strength loss is used rather than the prescribed conversion factor.

“Where the calculated loss of strength owing to corrosion is based on magnetic measurement of rope steel area, the indicated loss of steel area shall not exceed that area indicated by the specific instrument at which the rope strength loss due to internal corrosion is 10% of the new rope breaking strength”.

5.7

Several comments have been made regarding the allowable change in rope diameter. The following suggestions were made:

- Allow a further 1 mm diameter change over and above the limits given.
- Express the allowable wear as a percentage of the outer wire diameter rather than a percentage of the nominal rope diameter.
- A certain amount of bedding-in should be allowed. This is mainly plastic deformation (5.7.2) and should not be taken into account when calculating the discard factor.
- Calculate the change in diameter using the initial actual diameter as a basis. The actual diameter is to be taken during the first assessment of a new rope (as per section 6.2). In those cases where a mine does not allow the first assessment (in contravention of the safety standard), only the nominal diameter can be used as the basis.
- The actual diameter shall be $Da = Df - \frac{L}{Lr}(Df - Db)$

where Da = actual reference diameter to be used at distance L from the rope attachment

Df = actual diameter measured at the front end as per section 6.5.4.2 a) during the first assessment

Db = actual diameter measured at the back end as per section 6.5.4.2 b) during the first assessment

Lr = length of the rope excluding dead turns

Notes:

A record of actual diameters, measured with a pre-load of approximately 10% of the nominal rope strength, was obtained from the CSIR's rope test result records. Expressing the difference between the actual diameter and the nominal as a percentage of the nominal produced the distribution shown in Fig.8. The dotted line in Fig.8 indicates the diameter range covering two standard deviations. Approximately 97% of the diameters fall into this range.

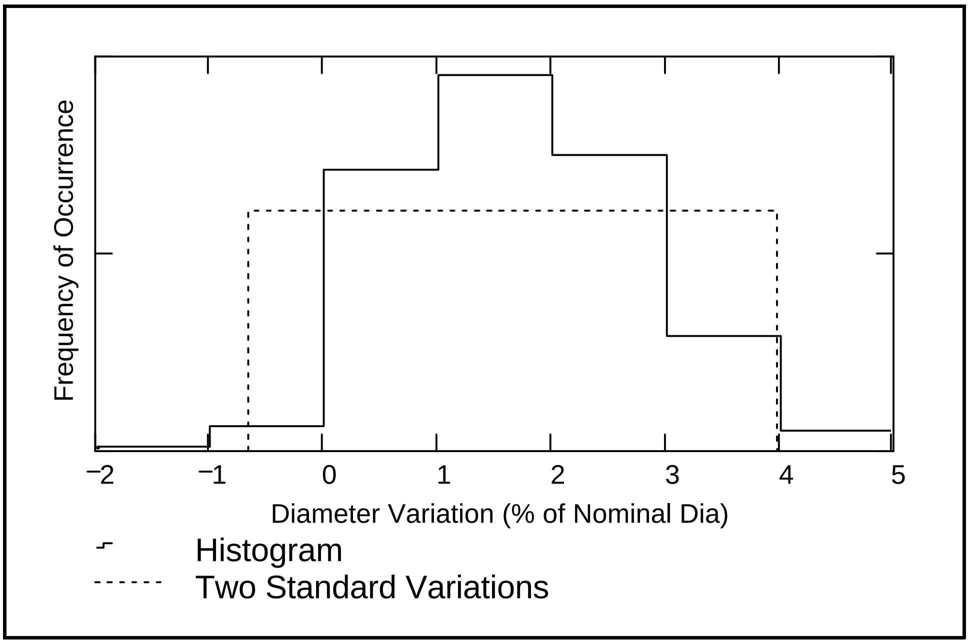


Figure 8 New rope diameter distribution

The variation in actual rope diameters is large when compared to the discard criteria and it would be appropriate to use the actual diameter at installation as a basis. If a discard criterion is chosen to make the allowable diameter reduction a percentage of the outer wire diameter, it is also interesting to know how the new rope diameter varies as a function of the outer wire diameter. This is shown in Fig.9.

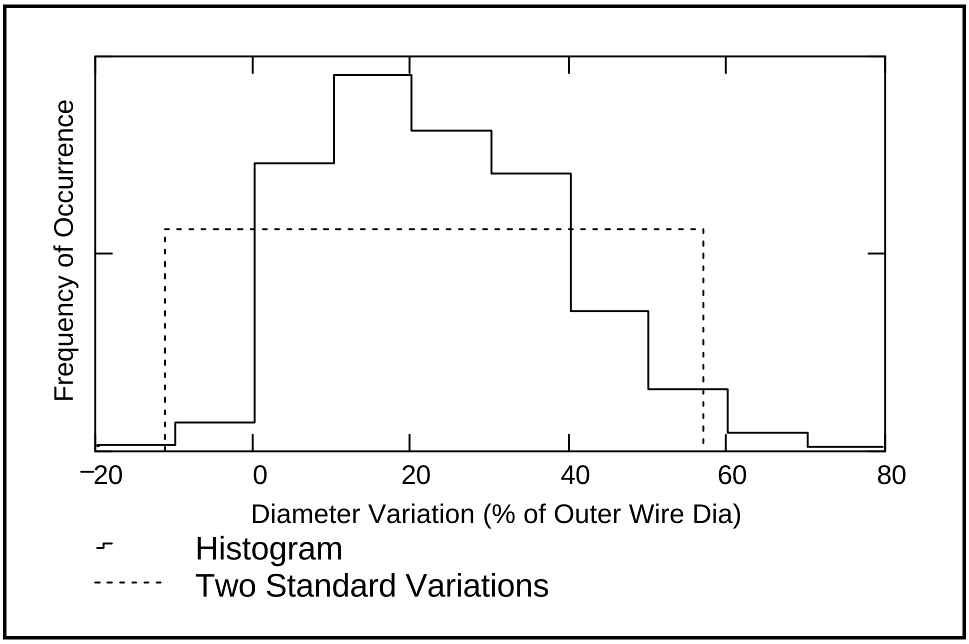


Figure 9 New rope diameter variation compared to outer wire diameter

A recommendation to use a measured reduction in the rope diameter, rather than comparing the measured diameter with the nominal value, was made by Hecker et al (1998).

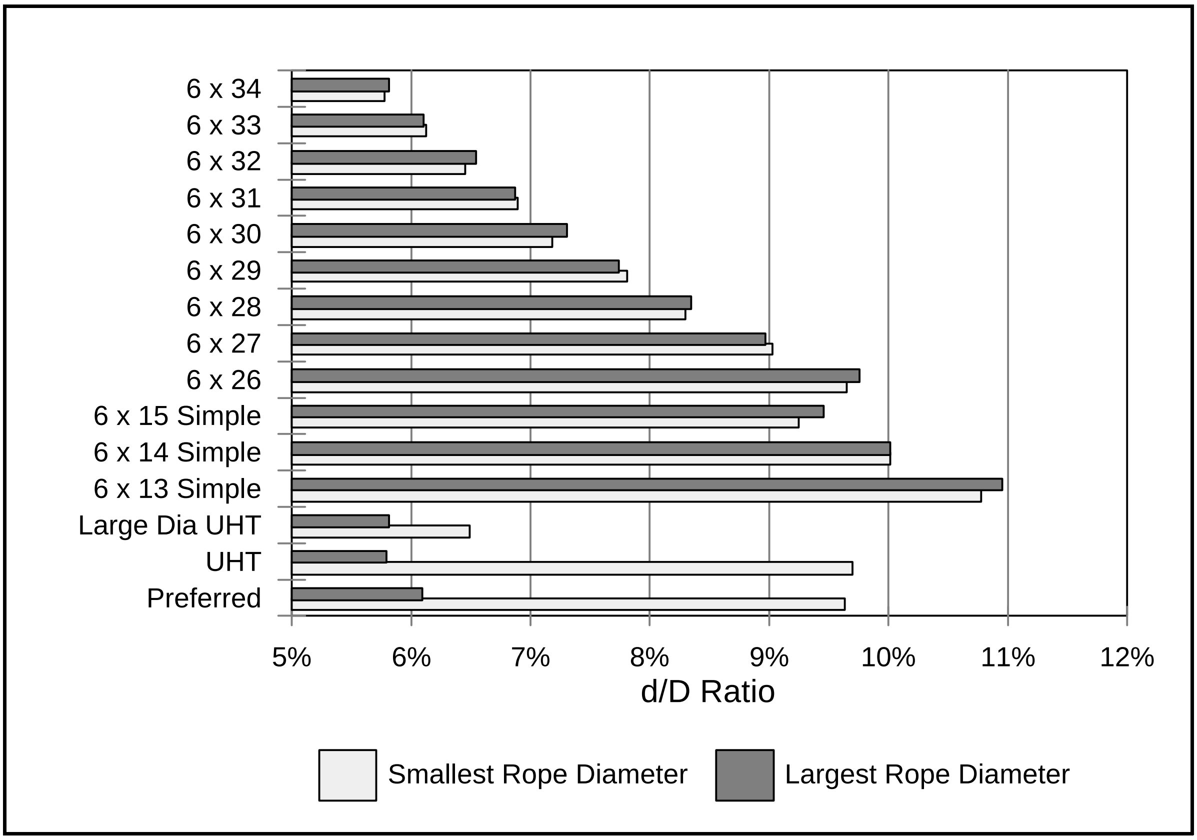


Figure 10 Outer wire diameter to rope diameter ratios for triangular strand ropes

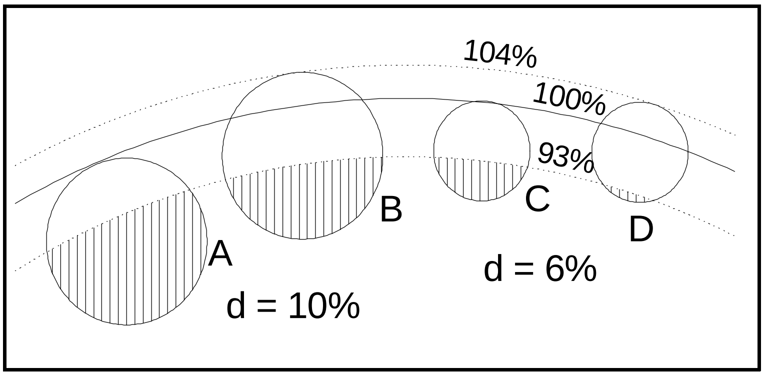


Figure 11 Illustration of allowable abrasive wear

Where a rope has an original diameter of 4% above nominal and gets discarded when the diameter is 7% below nominal, its diameter has reduced by 11% of nominal. In this case there would be between 0% and 50% of the outer wire area left. Example D in Figure 11 shows the case where the wire diameter is 6% of the nominal rope diameter and the rope diameter has reduced from 104% to 97% of its nominal value.

In such a case the wire dimension has reduced by $\frac{104\% - 93\%}{6\% \cdot 2} = 91.7\%$ of its original diameter.

On the extreme is a rope with the original diameter equal to the nominal value and an outer wire diameter equal to 10% of the rope diameter (example D in Figure 11). The outer wire will now have reduced by $\frac{100\% - 93\%}{10\% \cdot 2} = 35\%$.

Rope inspectors have reported that the current discard criteria on rope diameter are too stringent. Clearly a revision is required.

5.8

"Distortions of a rope in their various forms (waviness, angular or severe bends, corkscrews ..."

Reference should be made to 6.5.6

5.8.1

"Waviness or corkscrews

The following limits shall not be exceeded:" (There is a duplication in the reference to the *nominal diameter*)

5.8.1 a)

"... shall not exceed 15% of the nominal diameter of the ropes." This makes the discard criteria for triangular strand and non-spin ropes the same and a) and b) can therefore be combined.

As a motivation for reducing the allowable wave amplitude it was reported that a 54 mm rope had a 7 mm wave (3,5 mm amplitude). With this amount of waviness (13% of diameter) there was a significant amount of noise and sheave vibration and it was considered prudent to discard the rope before it deteriorated more or caused damage to the headgear. The rope inspector recommended that the rope be discarded and this was done without a query.

A different rope displayed a 17% waviness. Here too, it was recommended that the rope be discarded and this was done without a query.

5.8.2

"Angular bends"

It has been suggested that bends without wear on the outer wires should not be a reason for discard. (The suggestion, however, may not have been made taking cognisance of the fact that a bend in a rope will wear faster than straight sections of the rope).

5.10.1 b)

A case was reported where the outer strands of a non-spin rope were rotated around the inner strands by the interaction between the sheave and the rope. The rope operated satisfactorily until it was discarded with a lay length change of 40%.

5.10.3 a)

An analysis of the stability of triangular strand ropes has shown that a dangerous condition exists when the lay length decreases by this amount. 20% would be a more realistic value. In the unlikely event when this cannot be achieved, it is always possible to let out some spin.

5.10.3 b)

15% or even 20% would be more appropriate in the light of the 40% over 6 lay lengths experience described above.

5.14

In some cases there is degradation of the wires in a rope that is normally only detected during a destructive test. When a test on the front end of a rope (without wear and broken wires) shows a reduction in strength, this should be brought into the calculation of the discard factor. The easiest method of achieving this is to multiply the number of broken wires by the factor

$\frac{10(Fn - Fb)}{Fn}$ if and only if the breaking force Fb is smaller than that Fn when the rope was new. This number of broken wires is then used in the discard factor calculation.

Appendix 3: Proposed other changes to SABS 0293

The following is a list of proposed changes to the document other than discard criteria. The items should be read in conjunction with SABS 0293:1996. Proposed text is given in parentheses.

3.1

"angular bend / dogleg: A section of a rope that is permanently deformed into an elbow-shaped bend."

3.6 and 3.7

It is unclear why ropes should be assessed at different intervals (6.2) depending on the winder that they are operating on. Where a winding plant does not conform to SABS 0294 *Code of Practice for the Performance, Operation, Testing And Maintenance of Drum Winders Relating to Rope Safety* it is not obvious that its ropes are safer just because the static safety factor is higher.

3.8

"... assumes a helical geometric ..."

3.9

"corrosion: Chemical degradation of the wires of a rope to their oxidized state or leading to material removal (erosion), resulting in the steel volume of a rope."

3.11

Leave out - see 3.1.

6.1.2

Comment: At present the instruments are tested by the manufacturer. It is therefore necessary for the manufacturer to obtain approval from the Chief Inspector.

6.2

It has been reported that some engineers do not make provision for the specified initial rope condition assessment.

Kuun (1996: 15) states that:

"In all cases the Class I design factor is somewhat lower than the Class II factor, and longer inspection intervals are allowed in the latter case. This distinction between the two classes of ropes is based on the old assumption that rope safety depends on the rope design factor. This is obviously wrong, as explained in the Introduction of this training module: rope safety depends entirely on how well the rope as well as the rest of the winding plant is designed, made, operated, inspected and maintained, and is not a function of rope design factor in isolation. It is obvious that the new safety standard for winding plant results in improved rope safety for Class I ropes compared with present conditions, and that rope inspection intervals for Class II ropes should be shorter - **not longer** - than for Class I ropes.

Very few ropes fall into Class I at present, and the longer intervals allowed for Class II ropes was a compromise to get agreement (during 1994) among the mining houses for acceptance of the SABS code on rope condition assessment. **This arrangement must be seen as purely temporary and will no doubt be rectified in the next revision of the code: all winding ropes must be inspected at the intervals now specified for Class I ropes.** In the meantime, it is the responsibility of the engineer to decide whether Class I or Class II inspection intervals should be applied to any given rope under his control."

6.3

Comment: In most cases the mines do not allow the rope inspectors to test the complete length of the rope because this would mean that the test instrument will have to be set up twice and that would cost too much shaft time. It was even reported that, in many cases, the back end of the rope is tested only at every fourth normal rope condition assessment. It is suggested that, in cases where the entire rope is not passed through the MRTI, at least a visual inspection be done and diameters be measured on those sections that are not tested magnetically.

6.5.3

Rope inspectors seem to be unaware of the importance of this section!

6.5.4.2

See comments on 6.3.

7.7

New rope inspectors are sometimes appointed when a mine changes ownership. In such cases the new rope inspector does not have access to the rope record file because SABS 0293 does not make provision for such an eventuality.

8.1.7.2.2

Such instruments are no longer in use and omission of this section should be considered.

8.2.4

Such an instrument is not available and attempts at manufacturing one were unsuccessful. This section should therefore be left out.

9.3

Include an appendix that contains an application form for a rope inspector examination as well as a checklist of all the pre-requisites for such an examination.

9.3.4 a)

An example of “the prescribed form” should be included in the document.

9.3.5

This section can be omitted since the required six year period from inception of the standard has expired.

D.1 c)

See comments on 8.2.4. There is no SABS approval for a straightedge.

D.3.1 a)

Rope diameter tapes with 0,25 mm intervals are not available.

D.3.3

This is presently not being done.

General

While SABS 0293 can be used by rope inspectors that have undergone the necessary training, it does not contain enough information for anyone else to use the document. This is especially applicable to the engineer. For this reason the document should include supplementary information that includes

- Illustrations of defects (dogleg, kink etc.)
- Additional examples of methods of deciding on whether a rope may remain in service

Appendix 4: Responses to the draft version of this report

A draft version of this report was circulated in September 2003. Comments from only two respondents were received. These are listed below, together with the results of follow-up investigations and a brief discussion.

Respondent 1

Comments received

> *Of concern is the statement made under point 5 "Section 4.2 has shown that the size of the problem is small enough..... ". Our main shaft Koepe head ropes are running at 1.7 million Rand a set. I do not call this a small enough problem to justify conservative discard criteria. It takes a lot of effort and man hours to change these ropes. Any extension in life is a benefit to our operation which has a life of mine until 2015.*
>
> *Another point, since we have moved to galvanised ropes we have not had one rope discarded prematurely for corrosion. No one from SIMRAC has ever approached us for test pieces. Not even our rope inspectors have requested this from us. I have had numerous ropes discarded over the last two years because of internal wire failures yet no-one has ever requested them. The rope life graph represented at the start of the document looks like my X [name changed] shaft Koepe winder. The last three sets all failed due to corrosion. We addressed the problem and since then (May 2001) we have not lost a single set due to corrosion. Two sets have been lost due to mechanical damage and one set was lost due to internal broken wires.*
>
> *What we experience with Koepe ropes is that they stretch throughout their life. The rate of elongation gets less and less towards the end of life of the rope. At a certain point rate at which broken wire counts increase, is the sign that the rope has worked/aged to a point where it is no longer as "elastic" as before. This is considered the time to discard the ropes. There has been no scientific data to*

confirm this action, but it has been determined purely by experience and has not let us down yet. It would be interesting to test ropes at this point to determine their actual loss in breaking strength.

If you require test pieces for further testing, please contact us and we can get a program together. Non-spin rope discard criteria is a major concern to us at Mine 1 and Mine 2 [names changed] as we each have two deep level Koepe winders installed. One has a 2000 metre length of wind and the other just under 1000 metres.

Follow-up investigation

The responsible rope inspectors were contacted and a report on ropes discarded from the mine in question was received which is summarised in the table below:

Date Installed	Date Discarded	Trips	Reason for Discard
2001-06-08	2001-09-30	18 159	Spot at 500m West side. Mechanical Damage 3 broken wires Strand A; 3 broken wires Strand B
2001-09-28	2002-03-05	45 000	Due to corrosion: East side 100m spot (6.25% loss in dia.)
2002-03-02	2003-01-07	88 263	Mechanical damage at 235m West side - External broken wires (4 crown and 1 filler)
2001-04-07	2002-02-26	103 039	Corrosion at 250m West side measuring 30.2 mm diameter
2002-02-26	2003-02-09	134 141	Excessive corrosion in capels, ropes can't be pulled in anymore. External broken wires
2003-02-09	2003-08-19	135 850	Mechanical damage 480m West side (External broken wires 3 crown and 2 filler.)

Comments on the comments

From the above table it can seen that external broken wires occurred as a result of mechanical damage to the ropes. Significant improvements in rope lives were obtained. If the reported rope lives are indeed from the same winder as those depicted in Fig.2, the mine has already obtained improved rope lives. Had the ropes not been damaged and remained in service until fatigue set in, even longer rope lives could have been obtained.

The comment that ropes are discarded when they no longer stretch is not reflected in the summary table. It is known that ropes settle throughout their lives. Most of the settling occurs during the first few cycles. Usually the rope's strength increases as it settles because the load distribution between the wires becomes more uniform. The onset of fatigue damage, however, cannot be observed from the rope's elasticity. During a tensile test of a rope that is close to developing wire breaks, the modulus of elasticity will be very much the same as that when it was new but the plastic deformation before failure will have reduced.

Respondent 2

Comments received

> *1. P17. Internal broken wires : Is it really fair to discard on ANY indication of broken wires? According to the calculated discard factors, surely one is not reason for discard.*
>
> *2. P19. Currently SABS 0293 is not being interpreted as stated in GAP 803, in that rope inspectors are working on nominal diameter, and not on actual measured diameter when new, which can be 3 to 4 millimetres on a 54 mm rope, and this argument can be worse should broken outer wires be present. This results in premature discard of ropes. I can only assume that SABS 0293 will be changed accordingly.*

Will GAP 803 form part of SABS0293 similar to GAP 501, or will there be another SABS code ?

Comments on the comments

The first comment relates directly to the outcome of this project. The two proposed options (listed on p.17) for changing section 5.5.1 of the discard criteria allow no internal wire breaks and one internal wire break respectively. The first option has been suggested because breaks in the rope core and breaks in the inner rope can usually not be differentiated.

Appendix 2 provides a collation of information regarding the allowable diameter reduction. It was concluded by stating that *"Rope inspectors have reported that the current discard criteria on rope diameter are too stringent. Clearly a revision is required".*

Further investigations regarding an allowable rope diameter reduction are beyond the scope of this project.

It is not the intention that this report forms part of SABS0293. It's purpose was to provide discard criteria for non-spin ropes with internal broken wires. The additional items addressed in Appendix 2 and Appendix 3 were not within the scope of this report. They were, however, listed because they reflect the issues discussed during the interviews.