How effective is the non-destructive examination of multi-layer, low rotation winding ropes?

by M. Dohm*

Synopsis

The paper reviews the results emanating from an experiment conducted in Bochum—Germany in which various international rope inspection authorities were requested to assess the conditions of a corroded rope sample as well as a rope sample containing internal fatigue breaks. Both samples were of the multi-layer low rotation construction.

Introduction and background

The South African Minerals Act and Regulations required that 'A winding rope shall not be used if the breaking force at ANY POINT in the rope is less than nine-tenths of the original breaking load'.

The question of establishing the remaining strength accurately at any point along a rope, using non-destructive methods, has been a point of debate for many decades.

In the 1980s South African mining houses started identifying means of hoisting economical payloads from very deep shafts. One of the issues raised during these investigations was the efficacy of rope condition assessment. The investigations indicated that no common standard existed internationally for rope condition assessment. Tests of discarded ropes also indicated that the remaining strength varied greatly.

Numerous projects were funded, initially by the Chamber of Mines of South Africa, later by the Government, which addressed mine hoisting ropes in general and the condition assessment and discard criteria of ropes in particular. The focus was on six stranded ropes as these are predominantly used in the South African mining industry.

This work culminated in the publication of the SABS 0293: 1996: Code of Practice: Condition Assessment of Steel Wire Ropes on Mine Winders. This code is now applied throughout the South African mining industry by rope inspectors certificated in terms of the code by the South African Qualification and Certification Committee (SAQCC). Application of the code has led to enhanced safety and a reduction in operating costs.

Parallel research indicated that six stranded rope constructions, so commonly used in South Africa, may not be suitable for hoisting from great depths and that multi-layer, low rotation ropes may be required for this application.

Rope trials, funded by the Anglo American Corporation of South Africa Limited, Gold and Uranium Division, involving 48 mm diameter, low rotation, 15-strand fishback ropes at Vaal Reefs 9# during the early 1990s indicated that the NDT results of such ropes were suspect. In the final report relating to this rope trial the following was stated: 'Internal deterioration was suggested by anomaly indications appearing where no rope outer wire fractures were visible. Since the nature of this deterioration was unknown *the condition of the ropes could not be assessed accurately on the basis of the non-destructive, magnetic rope tests*'[3].

Numerous samples were cut from the ropes after discard. Three sections were de-stranded to ascertain the actual condition of the rope. It is interesting to note that no broken wires had occurred on the 9 outer strands of any of the rope samples. It was, however, disturbing to find 148 broken wires on the inner six strands of two of the 2-m long samples. In one sample 21 broken wires were found in an axial rope length of 100 mm. Figure 1 indicates the positions of the broken wires.

These results clearly indicated that the non-destructive testing methods employed by the South African mining industry at that time were not able to detect broken wires located on the inner strands of multi-layer ropes.

Representatives from the mining industry proposed a project to ascertain the defect detection capabilities of magnetic rope test

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instruments in respect of multi-layer, low rotation rope constructions on an international basis. This paper describes the results of the project.

Literature survey

Little reference was found to the actual resolution obtained by magnetic rope test instruments in the non-destructive testing of multi-layer, low rotation ropes.

While some of the papers suggest that internal broken wires can be identified accurately by means of magnetic rope test instruments, others seem to indicate this to be problematic, especially where a multitude of broken wires exist within a multi-layer, low rotation rope.

Similarly there are varying opinions regarding the remaining strength of corroded ropes. In some quarters there is the belief that sophisticated algorithms built into the instruments can lead to accurate predictions of the condition of corroded ropes.

The literature survey clearly indicated that there is no simple solution to the accurate identification of internal broken wires and the estimation of remaining strength of multi-layer, low rotation ropes.

Research methodology

Choice of methodology

The basic methodology proposed for the experiment was to fit a rope sample from the Vaal Reefs 9# experiment into a tensioning device and to have the rope examined non-destructively by a number of expert rope inspectors. After the non-destructive examinations had been completed samples of the rope would be destranded into its individual components to establish the position of each broken wire or destructively tested to ascertain its remaining strength. The NDE results would then be compared to the actual condition of the rope sample to establish the detection capabilities and resolution of the instruments.

It was decided to employ a discarded rope from the field with an unknown distribution of internal broken wires instead of a manufactured rope sample with known internal defects. The manufacture of rope samples with known defects is possible but time consuming. The resultant defects are not necessarily a replica of the wire breaks experienced under operating conditions. The choice of rope sample was discussed at a meeting with mining representatives and it was unanimously decided that rope samples from the field be employed.

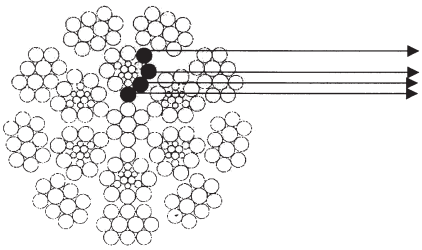

Figure 1—Position of broken wires within a multi-layer, low rotation rope sample

Furthermore, the non-destructive examination could either be conducted by an expert using his own instrument and performing the analysis of the instrument output signals himself whereafter the expert would submit a detailed report regarding the condition of the rope sample, or the researcher could subject each instrument to a series of pre-defined tests and then analyse the outputs from the various instruments and draw conclusions for each instrument tested.

From the literature survey it was quite clear that the efficiency of rope NDE is to a large degree dependent on the expert using his own instrument and his experience plus his understanding of the ropes being tested and his instrument. It was therefore decided to contract world-class rope NDE experts to conduct the examinations and for them to submit detailed reports.

Choice of NDE experts

Eight organizations were identified as having expert knowledge in the field of rope NDE. Several of these organizations produce the rope test instruments used for the examinations as well. Most have produced several papers in the field of rope NDE and have conducted research in this field.

The following were invited and accepted the invitation.

- NORANDA, from Canada
- Lloyds Beal Limited, from the United Kingdom
- DMT—Gesellschaft für Forschung und Prüfung, from Germany
- NDT Technologies, Inc. from the USA
- Universität Stuttgart—Institut für Fördertechnik, from Germany
- AATS—from South Africa
- The University of Mining and Metallurgy in Cracow, Poland. (The University withdrew from the project during the year because of high workload. The Polish instrument supplier Meraster was identified as a substitute)
- Rotesco Inc. from Canada

Choice of testing laboratory

Several test facilities were identified in Europe, South Africa and the United Kingdom. It was decided to conduct the experiment at the DMT—Testing and Transport Technology Laboratories in Bochum, Germany because two tensile testing machines of suitable capacity and length were available in one hall at the DMT. This facility allowed the NDE to progress in quick succession. The location is also convenient from a logistics point of view. Four of the NDE organizations were able to travel by car to Bochum.

Facilities were installed at both tensile test benches which allowed the test heads to be pulled back and forth over the ropes at various pre-determined speeds in a controlled manner.

Choice of rope samples

As stated earlier, it had been decided to employ discarded rope samples from the field for the experiment.

Corroded rope sample

The researchers were able to source a unique 36 mm diameter, 21 strand—21 (9 x 6 x 6) construction, multi-layer, low rotation rope of some 23 m length in very good condition except for an approximately 3 m length exhibiting heavy corrosion. This was an ideal sample because there were no broken wires in the sample and the bulk of the rope was in excellent condition, allowing for the calibration of the instruments on a good portion of the rope.

Broken wire rope sample

There were a number of 48 mm diameter, 15 strand 9 x 10 (8/2)/6 x 14 (8/6 + 3T)/WMC fishback, low rotation, multi-layer rope samples available from the experiment conducted at Vaal Reefs.

After discussions with experts in the rope testing field it was decided to use a rope sample exhibiting the least amount of damage. In theory, the fewer the number of clusters of broken wires contained within the rope under test the better the chances of accurate detection of the broken wires.

Various rope samples were examined, non-destructively, in great detail by AATS rope inspection personnel at the CSIR premises at Cottesloe. The 'best' rope sample, showing the least number of internal broken wires and 'noise', was identified and prepared for shipping to Bochum.

Test procedures

Corroded rope sample

The 36 mm diameter rope was installed into the tensile testing machine and pre-tensioned to 9,6 tons, which is 10% of the ultimate breaking strength of a new rope.

Each contractor was required to fit his instrument to the rope and prepare for the following tests:

Test 1

The contractor was required to obtain instrument traces of the rope, using a minimum instrument to rope air gap of 5 mm, for the following conditions:

- ➤ At an instrument velocity of 0,5 m/s in both directions
- ➤ At an instrument velocity of 1,5 m/s in both directions
- ➤ At an instrument velocity of 2,0 m/s in both directions
- ➤ At an instrument velocity of 2,5 m/s in both directions.

The traces were to be handed to the researcher directly after the test.

Test 2

The rope sample, some 21 metres in length, had a magnetic marker taped 5,35 m from one end of the rope. Two portions of the rope sample, each 3,75 m long, were marked off. The one portion was in the good section of the rope (test piece 1 or TP1) while the other covered the badly corroded section (test piece 2 or TP2). See Figure 2 for details.

The contractors were required to establish the remaining breaking strength of the rope at TP1 and TP2, where TP1 should reflect a breaking strength very close to the breaking strength of the new rope.

The contractors were also required to give an indication of the methodology employed during the test to establish the remaining strength of the rope and to substantiate the remaining strength estimates with calculations, calibration procedures, instrument traces, etc.

Broken wire rope sample

The 48 mm diameter rope was installed into the tensile testing machine and pre-tensioned to 20,8 ton.

Each contractor was required to fit his instrument to the rope and prepare for the following tests.

Test 1

The contractor was required to obtain instrument traces for the rope, using a minimum instrument to rope air gap of 5 mm for similar conditions as stated previously.

Test 2

The rope sample, approximately 18 m in length, had a magnetic marker taped to the rope at a distance of approximately 6,8 m from one end of the rope. The contractors were instructed to reference all broken wires identified in the rope by the NDE to this marker.

Three sections of the rope were marked off for specific analysis (see Figure 3 for clarity).

Contractors were required to examine the marked off sections of the rope in detail using NDE methods. Again an airgap of at least 5 mm was specified. Contractors were allowed to use any instrument velocity deemed necessary to conduct their tests.

After the examination, contractors were required to analyse the data and to submit a report to the researcher detailing the position and the number of broken wires identified in the rope, referenced to the marker for sections DS1 and DS2.

The contractors were also requested to submit the estimated remaining strength of section TP1.

Test 3

In the third test contractors were allowed, to non-destructively examine the rope in any other way they wanted in order to enhance the results of the examination.

Actual physical condition of the ropes

After the NDE tests had been completed in Germany the ropes were returned to South Africa for destructive examination.

Destranding and destructive testing of broken wire sample

The broken wire rope sample was sent to Haggie Rand Limited for analysis.

TP1 was destructively tested to establish the remaining strength of this particular rope section.

DS2 was destranded to establish the exact position and number of broken wires relative to the marker within the sample.

Results

Corroded rope sample

Table I summarizes the results of the non-destructive as well as the destructive test results for TP1.

Table I

Corroded sample: TP1 results

	Actual Breaking Strength in kN	Estimated Breaking Strength in kN	% Loss in Breaking Strength
Breaking strength of the new rope	961	-	-
Results of destructive test of rope sample	947	-	Approx. 1,46%
NDE results			
NORANDA	-	No significant loss	-
Lloyds Beal Limited	-	No significant loss	-
DMT	-	Nominal of new rope	-
NDT technologies	-	-	Assume 0%
Universität Stuttgart	-		Approx. 0%
AATS	-	No significant loss	
Meraster	-	800–940	between approx. 2,2% and 16,8%
Rotesco	-		Less than 1%

Table II

Corroded sample: TP2 results

	Actual Breaking Strength in kN	Estimated Breaking Strength in kN	% Loss in Breaking Strength
Breaking strength of the new rope	961	-	-
Results of destructive test of rope sample	497	-	48,3%
NDE results			
NORANDA			10% best case 20% worst case
Lloyds Beal Limited			greater than 14%
DMT			between 20% and 25%
NDT technologies			approx. 9%
Universität Stuttgart		At least 80% of new	not more than 20%
AATS		approx. 576kN	approx. 40%
Meraster		500kN to 690kN	between 28% and 50%
Rotesco			between 30% and 44%

Table II summarizes the results of the non-destructive as well as the destructive test results for TP2.

Broken wire rope sample

As stated previously contractors were required to assess the number of broken wires in the designated rope sections. Although the researcher requested that each broken wire identified by the NDE be referenced in axial distance from the marker, this was not attained in all cases. The resolution of a number of the instruments does not allow the inspector to pinpoint each broken wire accurately to the nearest mm or even 100 mm from a fixed point.

Many of the initial reports received by the researcher from the rope inspectors only stated the total number of broken wires per sample. The contractors were requested to

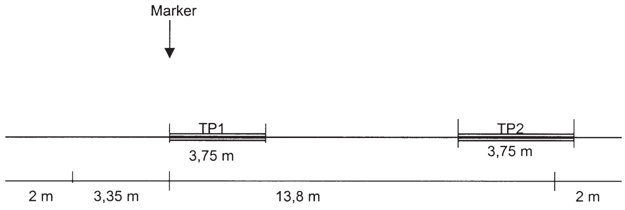

Figure 2—Corroded rope sample

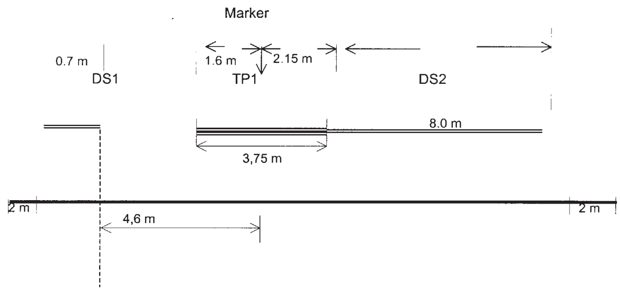

Figure 3— 48 mm rope sample with broken wires

supply more detailed information and to reference each broken wire identified to the marker. A number of contractors reported that this was impossible due to the resolution limits of their instruments and that reports would be submitted detailing the number of broken wires identified in 100 mm or even 200 mm intervals along the axial length of the rope.

A total of 609 broken wires were identified when the 8 metre rope sample, DS2, was destranded into its individual components. Rope condition assessment contractors identified between 0 and 750 broken wires in the same rope sample using non-destructive techniques.

Details of results: broken wire sample DS2–8 m length

Noranda

Test 2 results

The Noranda team identified a total of 31 broken wires along the length of the rope sample using the Magnograph II in terms of the procedures laid down for Test 2. These anomalies were classified on the trace as:

- Numerous internal broken wires (small diameter)
- Localized group of broken wires with added MA (possibly some bent back)
- Single broken wire (large diameter).

Each anomaly was referenced to the rope marker, i.e. an exact location for each broken wire was given relative to the marker.

Only 5% of the actual number of broken wires existing in the rope sample were identified.

Test 3 results

No results were presented.

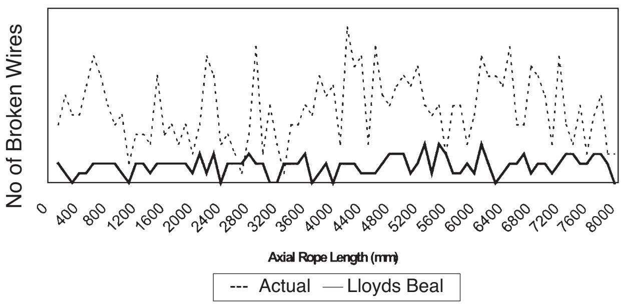

Figure 4—Lloyds Beal: Broken wire comparison for Test 2 at 100 mm intervals

Lloyds Beal

Test 2 results

Lloyds Beal personnel identified 142 broken wires in the rope sample, which represents 23% of the actual number of broken wires in this sample. The broken wires identified by Lloyds Beal were reported in the number of broken wires per 100 mm interval.

The details of the NDE are shown in Figure 4.

The graphs indicate that the inspectors were able to identify broken wires in areas of the rope sample where broken wires were physically present. However, some 77% of the actual broken wires were not identified.

Test 3 results

In this test Lloyds Beal inspectors used a 48 mm diameter insert in the test head. Results obtained were much better than in the previous test, in that 291 broken wires were identified in the rope sample. This represents 48% of the actual number of broken wires. Such tight inserts are, however, not practicable in the field where grease covers the ropes.

More broken wires were identified and there appears to be a correlation between some of the peaks in the graphs.

DMT

Test 2 results

The team from DMT identified 84 broken wires in the test sample which equates to 14% of the actual number of broken wires in the sample. They initially presented the number of broken wires in 1 metre intervals. This was later refined to 100 mm intervals.

Test 3 results

No results submitted.

NDT Technologies

Test 2 results

The rope test personnel from NDT Technologies stated in their report that they were able to identify 636 broken wires in the rope sample. This is 27 broken wires more than actually present in the rope sample.

The initial report contained a number of traces and the following comments:

‘All charts show large clusters of broken wires in areas along the length of the rope at the following distances;

- ➤ 0,3–0,7 m
- ➤ 2,5 m
- ➤ 4 m
- ➤ 5,4 m
- ➤ 10–11 m
- ➤ 12,4–13,5 m.

Besides these large clusters of broken wires, the LMA traces show considerable variations of cross-sectional area along the entire length of the rope. This, together with the indications of the LF trace, implies that there are innumerable broken wires and clusters of broken wires along the entire length of the rope’.

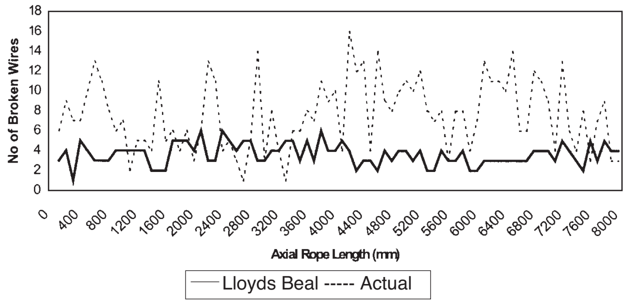

Figure 5—Lloyds Beal: Broken wire comparison for Test 3 at 100 mm intervals

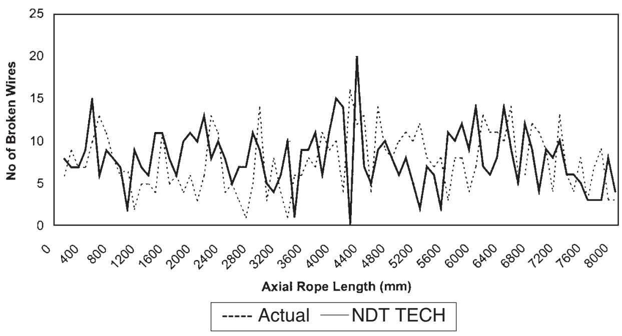

Figure 6—NDT Technologies: Broken wire comparison for Test 2 at 100 mm intervals

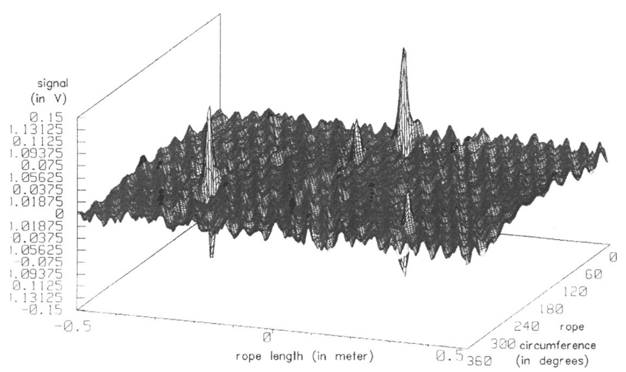

Figure 7—Stuttgart Universität—3D scan

At a later date NDT Technologies submitted an addendum to the initial report stating the number of wires identified in terms of 100 mm intervals.

Details of the results are shown in Figure 6.

The graphs indicate a correlation between the actual number of broken wires and those identified by means of NDT. There is an offset noticeable between some peaks, which may be due to an axial measurement error in the instrument. The graphs also indicate an overstatement of the number of detected broken wires in the areas closest to the marker and an understatement of broken wires in the 5 200 mm area.

Test 3 results

In this instance NDT Technologies personnel wound an annular coil onto their instrument to enhance resolution.

The rope inspectors identified 750 broken wires in the 8 metre rope sample. This is 23% more than the actual number of broken wires present in the rope.

Universität Stuttgart

Test 2 results

Personnel from the University identified 42 broken wires in the 8 m rope sample. This represents 7% of the actual number of broken wires in the rope. The report submitted to the researcher identified each broken wire in relation to the marker.

Test 3 results

The Stuttgart Universität rope experts also tested the rope using the 'Hochauflösende Magnetische Seilprüfmetode'. The inspectors identified the same number of broken wires using this method as they did using their normal instrument. Figure 7 shows a black and white rendition of a 3D scan.

AATS

Test 2 results—AATS instrument

The AATS team identified 341 broken wires in this rope sample, which equates to 56% of the actual number of broken wires. Some anomalies were classified as 'large'.

Each broken wire identified was referenced to the marker.

The results are reflected in Figure 8

These results indicate correlation between some of the peaks. In these graphs an offset between peaks is noticeable which may indicate a problem with the axial measurement system of the instrument. As with the NDT Technologies results, an understatement of the number of broken wires in the 5 200 mm area is evident.

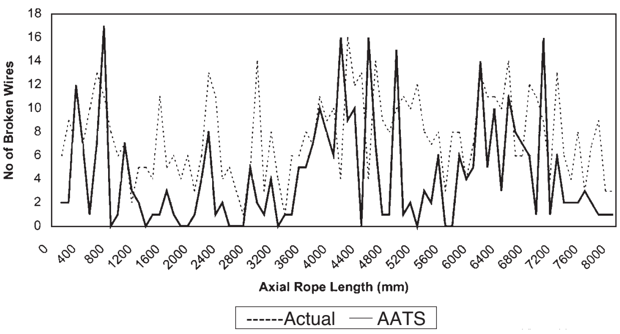

Figure 8—AATS: Broken wire comparison for Test 2 at 100 mm intervals

Test 2 results—RMS instrument

AATS personnel repeated the test using a second instrument. This instrument is directly coupled to a chart recorder and the analysis of the results was entirely dependEnt on the chart. In this test 67 broken wires were identified in the sample.

The results were submitted in terms of 'number of broken wires per 200 mm interval'.

Test 3 results

No results were submitted.

Meraster

Test 2 results

The rope inspectors from Meraster identified 19 anomalies in the rope sample. These anomalies were each referenced in mm from the marker. Each anomaly was described, for example

- accumulated broken wires of inner strand
- accumulated broken wires of rope core
- inner, 2 or more wires
- WMC, 2 or more wires
- outer, 2 or more wires.

The researcher was unable to obtain a more detailed breakdown of the number of broken wires identified by Meraster.

Comments by Rotesco	
a) Position and number of broken wires identified in the rope, referenced from the marker (Rotescograph Test)	No broken wires were positively identified in the rope from the Rotescograph Test Results. None were identified because the signals from the broken wires, if there were any, were masked or were indistinguishable from the signals caused by other types of deterioration, which appeared to be wear and possibly internal nicking.
b) Position and number of any additional broken wires identified in the rope from other tests (Solenoid test)	A 64 mm diameter solenoid coil was placed inside the Rotescograph Test Head and the rope was tested using this solenoid coil. The output from the solenoid coil was integrated to provide a signal of the loss of metallic cross-sectional area. Based on the test results from the solenoid coil, no broken wires were positively identified in the rope. None were identified because the signals from the broken wires, if there were any, were masked or were indistinguishable from the signals caused by other types of deterioration, which appeared to be wear and possibly internal nicking.

Test 3 results

No results were submitted.

Rotesco

Test 2 results

Rotesco identified no broken wires in the rope sample.

Test 3 results

A solenoid coil was wound into the instrument for this test. Using this method no broken wires were positively identified on the rope.

Results of Test No 1

A quantitative comparison of the traces was difficult because of the different chart speeds used for different tests.

The analysis of the traces indicated that the velocity of the instrument and the direction of travel influenced the output signal of certain of the instruments. This can affect the repeatability and accuracy of the rope condition assessment.

Remaining strength of section TP1

The rope condition assessment contractors were all requested to determine the remaining strength of the rope section designated as TP1 in the 48 mm rope sample.
Only one took the challenge.

The fact that only one contractor tried to estimate the remaining strength of the rope sample gives an indication of the complexity and difficulty in estimating the remaining strength of ropes.

DMT experimental rope containing artificial defects

The DMT made their in-house experimental rope available for further tests to all of the rope inspection organizations which took part in the Bochum experiment. The experimental rope is a multiple oval, flattened strand rope of 48 mm diameter and SES-U+7x[1+6+(6+6)+16] construction. The rope is mounted on a vertical position and the test heads are moved up and down over the rope by means of a crane.

The rope has a number of artificial defects built into it ranging from single broken wires to a broken core.

All 8 rope inspection teams were able to identify every anomaly in the rope.

Analysis and discussion

Corroded rope sample

- ➤ The wide variation in the remaining strength values submitted by the different rope inspectors gives an indication of the complexity and the unknowns inspectors have to contend with when deriving the remaining strength of corroded rope sections. The wide spread of results further indicates the lack of international standards for the condition assessment of corroded ropes.
- ➤ The loss of metallic area (LMA) determined by the various rope inspectors varied considerably. It must be noted that the percentage LMA is a relative measurement. It is usually a comparison of the measured metallic area (MA) in one section of the rope (usually a 'good' section of rope where the instrument is calibrated) with the measured MA in another section of the rope (the deteriorated section). The measurement of the LMA should be relatively straightforward.
- ➤ The values presented for %LMA varied from 9% to 45%, in relation to the good section of the rope. This indicates that calibration and measuring procedures are not universal nor adequate. Different instruments used to measure the same rope section should at least give reasonably similar LMA values.
- ➤ The derivation of the loss of breaking strength (LBS) was presented in different ways by the different rope inspectors. Some of the experts used formulas to calculate the LBS, others used graphs, some multiplied the LMA value by two while others halved the LMA value they had recorded. One inspector gave the remaining strength estimate within a very wide tolerance band.
- ➤ The rope condition assessment experts calculated LBS values of between 9% and 50%. This must be compared to the actual value of 48,3% LBS established by destructive testing.
- ➤ The above also indicates a lack of consistency in the methodologies and standards rope inspectors apply to determine the loss of breaking strength. This fact should be of grave concern to users employing ropes in critical applications.
- ➤ The researcher is not keen on relying on the proprietary algorithms proposed by certain inspectors for assessing the condition of ropes. These proprietary algorithms lead to a 'black box' approach. The user of the instrument generally does not understand the reason for rope discard when using this proprietary technology built into the instrument.
- ➤ For the algorithms to be useful every combination of rope construction, deterioration mechanism, rope diameter, tensile grade and instrument characteristic needs to be tested and compared to the actual LBS of the ropes under review to demonstrate the reliability of the algorithm.
- ➤ In the South African context, the researcher has seen instances where the LMA traces indicated very little signs of deterioration and the LF trace showed no anomalies, yet the ropes had lost more than 35% of their original breaking strength. The loss in these instances was due to very localized abrasion of the crown wires over a short section of the rope.

Table III

Remaining strength comparison of 48 mm rope, TP1

	Strength of TP1	% Reduction in strength
Breaking strength of new rope	2080 kN	
Actual remaining strength as determined by destructive test	1452,7 kN	30,2%
Noranda	-	-
Lloyds Beal	-	-
DMT	-	-
NDT Technologies	-	-
Universität Stuttgart	-	-
AATS	-	-
Meraster	-	-
ROTESCO		4% to 6%

- It is therefore imperative to visually examine all indications of anomalies diligently and to combine the results obtained by the visual examination, measurements and magnetic tests with the in-depth experience of the rope inspector. The researcher suggests that the 'black box' approach be avoided.
- The South African Bureau of Standards Code of Practice 0293: 1996 'Condition assessment of steel wire ropes on mine winders' provides good guidelines for establishing the condition of corroded ropes by means of NDE, even though it is a time consuming process.

Assessment of the broken wire rope sample

- Although the researcher attempted to choose the 'best' rope sample, with the least number of broken wires, from the samples available for the experiment, the chosen rope still contained up to 24 broken wires/100 mm rope length at the worst spot. The 8 m section of the rope sample, which was subjected to intense analysis, contained 609 broken wires. The rope inspectors identified between 0 and 750 broken wires in the same 8 m rope sample applying NDE methods. It must be noted that the ropes from which the samples were cut were in service on a mine until discarded in terms of the discarded criteria available at that time (1993). The same discard criteria apply today.
- The large number of broken wires contained in the rope made the examination and analysis of the rope condition more difficult than having fewer broken wires.
  The results of the experiment clearly indicate that the rope inspectors were unable to identify each broken wire in the rope accurately. Two of the inspectors were able to identify a large percentage of the broken wires. It must however, be noted that both these contractors were unable to identify the numerous clusters of broken wires situated around the 5200 mm mark.
- The lack of response by rope inspectors to estimate the remaining strength of a portion of the rope gives a clear indication that inspectors are loath to derive remaining strength estimates for any ropes. Only one rope inspector calculated the LBS at between 4% and 6%. Actual LBS was determined by destructive test to be 30,2%.

Alternative instrument configurations

The results clearly indicate that the annular coil configuration coupled with small airgaps improves the sensitivity of the instruments. This configuration is however impractical in the field.

Conclusions

Corroded rope sample

- The loss of breaking strength (LBS) values presented by the various rope inspectors varied between 9% and 50%. This clearly indicates the complexity inspectors have to deal with when determining the LBS of corroded ropes and the lack of standards.
- The large variation in the loss of metallic area (LMA) determined by the inspector, between 9% and 45%, indicates that calibration procedures and measuring procedures are not adequate nor universal.
- The wide variation in the methodologies of calculating the loss in breaking strength (LBS) indicates a lack of consistency in the procedures and standards rope inspectors apply.
- Inspectors must be wary of implementing a 'black box' approach, when assessing the condition of corroded ropes.
- The SABS 0293 guidelines for assessing the condition of corroded ropes provide a good basis for rope NDE, even though it is time consuming and laborious to conform to these guidelines.

Broken wire rope sample

- Magnetic rope test instruments are not able to identify each wire break within multi-layer, low rotation ropes.
- The results indicate that instruments are not capable of pin-pointing broken wires accurately, not even to the nearest 20 mm, along the axial length of the rope.
- From the material presented by the rope inspectors it is obvious that it is not possible to ascertain the radial position of the broken wires within multi-layer, low rotation ropes.
- Given the above, it must be concluded that it is not feasible to implement discard criteria for multi-layer, low rotation ropes based on the premise that the accurate identification of the axial and radial position of wire breaks within the rope by means of magnetic NDE is possible.
- As stated in the conclusion to the literature search, a vast amount has been written about non-destructive rope testing and many successes have been claimed in this field. Application of high-tech computerized systems are seen to be able to automate and deskill rope NDE. The experiment conducted at Bochum, however, indicates that rope NDE in practice is not as advanced as claimed in the literature.

General

The researcher noted that the output signals from several instruments were influenced by the speed and the direction in which the test head travelled. This can influence the NDE results negatively.

Acknowledgement

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