
Guidelines for examination, testing and discard of mine winder ropes

- For use in coal mines

MDG 26

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Foreword:

This guideline has been prepared to assist Manufacturers, Purchasers/Owners/Operators, Site Contractors and the Department of Mineral Resources Coal Mining Inspectorate to assess safety aspects and in particular retirement criteria for winding ropes. Safety aspects include rope life extensions, inspections, competency and technical considerations for retirement of ropes.

Mine winders whether friction or drum type, whether drift or shaft, utilised for the purposes of winding men, materials or coal are vital items of machinery for the success of that mine. It is imperative to manage such equipment for the ongoing safety and effectiveness of the business.

Conversely it must be recognised that mine winders represent a core risk to the business and safety of personnel. Management systems and appropriate hardware to mitigate such risks are necessary.

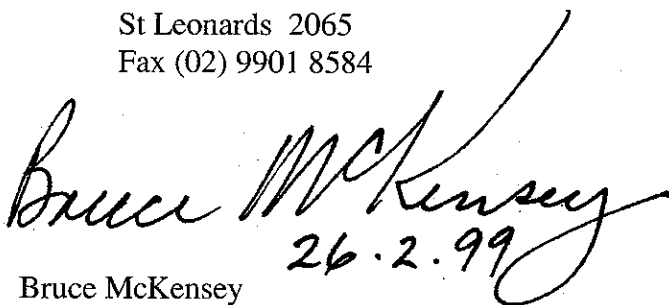
Current legislation codes and guidelines with respect to mine winders, are the result of an accumulation of historical disasters (eg Markham). Processes for risk management as applicable to mining equipment can be found in MDG 1010 "Risk Management Handbook for the Mining Industry". Also available is MDG 3004 SR95/1 "Summary of Mine Winder and Shaft Incidents in New South Wales Coal Mines".

This guide applies to all winder ropes including drift and shaft haulage ropes, guide ropes, rubbing ropes, head ropes and balance ropes on Coal Leases in New South Wales. Such application may be demonstrated in MDG 33 "Guideline for Design, Commissioning and Maintenance of Drum Winders".

The construction evaluation and input provided by Mr D Ng, and Ray Johns of Workcover Authority, Mr H Tiller of BHP Lifting and Industrial Products, Mine Mechanical Engineers-in-Charge and Inspectors of Mechanical Engineering including Messrs Roberts, Koppe, Hoerndlein and Jervis is gratefully acknowledged.

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1 Scope and General

1.1 Scope

This guide-line is intended to assist in the development of a safe management system for winding ropes by establishing an engineering basis for rope examination testing and discard criteria for all ropes used in association with friction and drum winders, including drift winders.

Although this guideline does not detail all aspects of a safe rope management system many of the critical elements are included, such as:-

- a) the competence of personnel to identify defects and assess the cumulative effects of the various contributions to rope deterioration.
- b) a consistent, staged, conservative and documented approach to ensure rope deterioration does not result in the use of ropes without an adequate factor of safety
- c) the considerations needed to cover specific site conditions.

It is assumed that all rope management systems will include an appropriate audit/review component.

The Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation 1984 provides service life and safety factor criteria as well as examination and test requirements for winder ropes. This GUIDE-LINE includes further recommendations for the safe use of wire ropes associated with winding equipment to assist in meeting the requirements of the Occupational Health and Safety Act 1983, N° 20, Part III Division 1.

For winding ropes the most definitive way of identifying the strength of the rope and hence verifying the safety factor is through the destructive testing of a representative section of rope. The factor of safety calculation as defined using the destructive test result is in reality only applicable for that end section of the rope which is destructively tested. Other areas along the rope may well have less or greater strength. It is intended in the GUIDE-LINE to provide guidance relating to the discard of ropes based on the total condition of the rope as ascertained by a number of available methods of condition monitoring.

The continued use of wire rope should not be based on any single test but rather on a combination of a number of tests ie. do not rely on non destructive tests alone.

1.1.1 The GUIDE-LINE is intended to assist mine and contractor personnel in meeting the requirements of the Occupational Health and Safety Act 1983 by establishing criteria for the discard of friction winder and drum winder ropes. It is not intended to be all encompassing or limit innovation in establishing such criteria.

In addition to this document it is recommended that the appropriate risk management technique and risk assessment process be utilised to ensure the safe operation of wire ropes. Refer to MDG 1010 and MDG 1014 for guidance.

NOTE “shall” and “should”

- **Shall** Means that the requirement is strongly recommended if it is applicable to the type of equipment under consideration unless it is used in association with a legislative requirement then it is mandatory.
- **Should** Means that the requirement is recommended.

If any of the parameters as recommended under a “shall” or “should” instruction are not adhered to, the mine or contractor should justify the alternative to the recommendation through a process of technical assessment, risk assessment and risk management.

- 1.1.2 Unless otherwise specified, the appropriate Australian Standard shall apply.
- 1.1.3 The guideline shall not in any way negate the requirements of the Coal Mines Regulation Act 67/1982 nor the Occupational Health and Safety Act, 1983, No. 20.
- 1.1.4 Any approval application for the purposes of gaining a friction winder rope life extension shall meet the requirements of MDG 1010 Risk Management for the Mining Industry.

This should be done once for each installation to ensure everything is covered and then only revised as appropriate for future life extensions.

1.2 Reference Documents

- 1.2.1 Occupational Health and Safety Act, 1983, No. 20.
- 1.2.2 Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation, 1984. Extracts from this document are used throughout the Guideline. Typically for example R12.6 would designate that the preceding information was sourced from Clause 12(6) of the Coal Mines Regulation (Shafts and Roadways - Underground Mines) Regulation.
- 1.2.3 MDG 1010 Risk Management Handbook for the Mining Industry
- 1.2.4 MDG 1014 Guide to Reviewing a Risk Assessment of Mine Equipment and Operations
- 1.2.5 AS1735.2 SAA Lift code Part 2 - Passenger and goods lifts-electric
- 1.2.6 AS2759 Steel wire rope application guide.

- 1.2.7 AS3569 Steel wire ropes.
- 1.2.8 DR97350 Australian Draft Standard for Non Destructive Examination of Wire Ropes
- 1.2.9 United States of America Code of Federal Regulations 30 subpart 0 sections 77.1400 to 77.1438 inclusive and 75.1429 to 75.1438 inclusive.
- 1.2.10 ASTM E1571 - 93 Standard Practice for Electromagnetic Examination of Ferro Magnetic Steel Wire Rope.
- 1.2.11 The Ropeman's Handbook - National Coal Board London
- 1.2.12 SABS 0293 Condition assessment of steel wire ropes on mine winders code of practice
- 1.2.13 BS6570 British Standard Code of practice for the selection, care and maintenance of steel wire ropes
- 1.2.14 ISO4309 Cranes - Wire ropes - code of practice for examination and discard

1.3 Definitions

- 1.3.1 Actual Breaking Force - actual tensile force in kilonewtons required to break a test sample of the rope as nominated on either the Manufacturer's original test certificate or the most recently issued destructive rope testing certificate.
- 1.3.2 Actual diameter - the measured diameter as per AS2759 Steel wire rope application guide Section 2.6.
- 1.3.3 Approved - means approved by the Chief Inspector of Coal Mines
- 1.3.4 Balance rope - one or more wire ropes connecting the undersides of a pair of conveyances.
- 1.3.5 Base line diameter of the rope - the actual diameter of the rope measured at the point of maximum static load when rope is newly installed and under tension.
- 1.3.6 Competent Persons - a person having practical theoretical and legislative knowledge and relevant experience sufficient to enable that person to detect and evaluate any defects or weaknesses that may affect the performance and or legislative compliance of the wire ropes associated with winding equipment.

Note: This does not preclude two (2) difference persons combining their efforts to achieve the appropriate level of competency eg a person competent in the use of NDT examination of wire ropes and a person competent in the other required areas.

- 1.3.7 Conveyance - any car, carriage, cage, skip, kibble or stage in which persons, minerals, or materials are wound through a mine shaft, and any counterweight.
- 1.3.8 Guides - stiff structural members or suspended steel wire ropes located in a mine shaft or sky shaft or both, to limit lateral movement of the conveyance.
- 1.3.9 Diameter of rope - is the transverse measurement through the centre of the smallest enclosing circle around the cross-section of the rope.
- 1.3.10 Drum winder - a winder having a driven drum or circular cross-section which acts as a rope coiler and anchors one end of the rope. Such drums may be cylindrical, conical, or cylinder-conical.
- 1.3.11 Friction Winder - a winder with one or more drive pulleys which drives the winding rope by friction developed between the rope and the driver pulley.
- 1.3.12 Head rope - one or more wire ropes connecting the topsides of a pair of conveyances.
- 1.3.13 "management plan" means a document which specified the outcome of work and how the work is to be carried out to ensure the installation use and maintenance of mechanical equipment is without risk to health and safety.
- 1.3.14 "management system" means a documented self monitoring process set in place to achieve an outcome or series of outcomes as defined in a management plan and which is capable of being independently audited to existing Standards so that expected outcomes of work are being achieved.
- 1.3.15 Minimum breaking force - the minimum tensile force in kilonewtons as guaranteed by the Manufacturer's original test certificate
- Note:** Verification of this value is obtained from reference to the value recorded for actual breaking force.
- 1.3.16 Nominal diameter of the rope - the diameter used for size classification for purposes of description.
- 1.3.17 Non Destructive Examination - NDE an examination using non-destructive testing equipment and visual examination.
- 1.3.18 Non Destructive Testing - NDT - an examination using magnetic detecting and recording instruments, unless otherwise stated.
- 1.3.19 Risk Assessment: the overall process of risk analysis and risk evaluation, refer to MDG 1010 and MDG 1014.

- 1.3.20 Risk Management Process: the systematic application of management policies, procedures and practices to the tasks of analysing, evaluating and controlling risk.
- 1.3.21 Rope area - metallic cross-sectional area of a wire rope (excludes the area of any non metallic core).
- 1.3.22 Rubbing ropes - suspended steel wire ropes, installed between closely spaced rope-guided conveyances.
- 1.3.23 Visual Examination - the physical examination of a rope by a competent person or by a person nominated, as detailed in Section 4.2.2 of this guideline.
- 1.3.24 Winder - a machine primarily used for raising and lowering through a mine shaft or roadway by means of a winding rope (s).
- 1.3.25 Wire rope - a group of strands laid helically and symmetrically, with uniform pitch and direction around a central core of natural or synthetic fibre, or wire.

2 Factors of Safety

- 2.1 The rope breaking force - to be used for calculating the Rope Factor of Safety for the winding installation shall be the lessor of either the minimum breaking force for the rope when new or the actual breaking force.
- 2.2 Drum winder rope factor of safety - shall be calculated by dividing the breaking force of the rope (refer 2.1), by the sum of the maximum load to be raised or lowered by the rope plus the total mass of rope acting as load due to gravity when fully let out. Reference is made to R12.6 and R16.7.

The following factors of safety for drum winder ropes shall be used as per the Coal Mines regulation (Shafts and Roadways - Underground Mines) Regulation 1984:-

- 2.2.1 Transport of personnel - "when newly installed shall not be less than 10." "A rope other than newly installed shall not be used if the factor of safety falls below 8. Reference is made to R12.4,5.
- 2.2.2 Transport of other than personnel - when newly installed shall not be less than 8. A rope other than newly installed shall not be used if it's factor of safety falls below 6. Reference is made to R16.5,6.

2.3 Friction Winders

- 2.3.1 **Friction Winder Head rope factor of Safety** is to be calculated as detailed in Appendix A & B
- 2.3.2 **Head Ropes Generally: For friction winder head ropes the rope should not be used if the rope breaking force (strength) falls below 90% of that required when the rope is new.**

2.3.3 Friction winder balance rope(s) factor of safety:-

2.3.4 The breaking strength shall not be less than six times the total weight of the rope. Reference is made to R14.2.

2.4 Guide Ropes and Rubbing Ropes

2.4.1 Every guide rope and rubbing rope used at a mine shall, when newly installed, have a breaking force at the point of suspension of not less than 5 times the heaviest static load to which the rope may be subjected. Reference is made to R15.

The ropes referred to above should not be used if the factor of safety falls below 90% of that required when the rope is new.

3 Testing

3.1 General

In general destructive testing should not be substituted for non destructive testing because generally the sample of rope used for destructive testing may not represent the section of rope that has deteriorated the most. Non destructive testing will give a better indication of the condition of most of the rope. Visual examination needs to be used in addition to testing to ensure ropes remain in a safe condition.

3.2 Regulatory Test Requirements -

3.2.1 All new ropes shall not be used unless a manufacturers certificate is held by the Mine Manager which sets out the date of manufacture, diameter and circumference, actual and minimum breaking force, length and the mass per metre of the rope. Reference is made to R12.2.

3.2.2 All destructive testing shall be carried out by an approved testing authority. This means approved by the Chief Inspector of Coal Mines. Reference is made to R16.1a.

3.2.3 All non destructive testing shall be carried out by an approved testing authority. Reference is made to R16.1b.

3.2.4 The following provisions shall apply to haulage ropes used in or about a mine Reference is made to R16.1.

- a) Subject to the substitution with non-destructive testing indicated in 3.1 at least once in every 6 months all shaft winding ropes (other than ropes used in friction winding apparatus) and all other ropes in a system for transporting persons (other than ropes used in endless rope systems) shall be subject to a destructive test carried out by an approved testing authority. Reference is made to R16.1a.

- b) Every second one of the tests referred to in 3.2.4.a may be replaced by a non-destructive test carried out by an approved testing authority. Reference is made to R16.1a.

3.2.5 For friction winders it is *generally* required that non-destructive testing be conducted at frequencies not exceeding the following periods:-

Period from Date of Installation (Years)	Head Rope Test Frequency (Months)	Balance Rope Test Frequency (Months)
0 - 2	6 ®	12 ®
2 - 3	6	12 ®
3 - 4	5	10
4 - 5	4	8
> 5	3	6

Note: The items marked ® in the above table are the requirements as detailed in the regulations (reference R16.1e and R16.1d).

Other nominated frequencies are those generally included as a condition of approval for rope life extensions.

3.3 Further Recommended Tests

3.3.1 General

- a) All new ropes used in a winding system should be non-destructively tested within four (4) weeks of being placed in service after initial rope stretch but before visible rope wear occurs. (To obtain a reference record for future comparison purposes). This will establish the extent or otherwise of any anomalies in the rope as may have resulted during manufacture, installation or storage.

Diameter measurements as per Clause 4.4 should also be conducted at this stage, refer also Section 4.6.7.

- b) The frequency of non-destructive testing of all ropes used in any part of a winding system should be based on:-
- Legislative requirements
 - Consideration of historical data, including variation to operational and maintenance details.
 - A maximum period of 12 months if Legislative requirements are not stipulated and historical data is not available, unless otherwise stated in this document.
 - The degree of rope deterioration as further detailed in Clause 3.3.2

- The further considerations as detailed in Clause 3.3.2, 3.3.3, 3.3.4, 3.3.5.

3.3.2 More frequent non-destructive tests should be conducted if:-

- the rope is used for the haulage of men
- the system uses a single rope for haulage of men (as opposed to multiple ropes)
- the minimum permissible factor of safety is being approached
- the maximum permissible life is about to be reached
- metallic area loss exceeds a pre determined figure for the type of rope construction and duty (eg 6% area loss for most winding ropes but may be as low as 4% for short life drift ropes).
- an anomaly is suspected
- deterioration of a rope is indicated by:-
 - a) significant corrosion relevant to the diameter of the individual wires.
 - b) presence of broken wires which have not been identified as being insignificant.
 - c) noticeable wear of the outer wires
 - d) loss of rope diameter since original settling in period
 - e) the number of broken wires is increasing
 - f) fatigue failures of wires are indicated
 - g) a kink is or has been present
 - h) increase in rope diameter.

NOTE:- IT IS RECOMMENDED THAT A SAMPLE OF NEW ROPE BE RETAINED FOR COMPARISON AND CALIBRATION PURPOSES FOR NON - DESTRUCTIVE TEST PURPOSES, TO ALLOW THE LOSS OF AREA OF A WORN ROPE TO BE EXPRESSED AS A %. OF THE UNWORN ROPE, ALTHOUGH THE BIGGER AIR GAPS IN A NON-TENSIONED SAMPLE MAY NOT BE IDEAL FOR NDT.

3.3.3 All drum winder haulage ropes should be non-destructively tested at intervals not exceeding 6 months. (destructive testing of a non-wear end of a rope may not *provide* a realistic measure *of the* minimum *breaking force* of a rope in *service*).

3.3.4 For friction winders it is recommended that destructive testing of a section of rope be conducted when the rope has been in service for 5 years and then at 3 yearly intervals to ensure that excessive reliance is not placed on non – destructive testing. This may require the use of extra links to maintain fixed length between docking positions.

For multiple rope systems it may be appropriate to test one (1) end of one (1) rope after five (5) years then one end of another rope each three (3) or less years thereafter.

3.3.5 Guide or rubbing ropes including anchor points and attachments should be tested using non-destructive testing according to the frequency in the following table:

Guide or Rubbing Rope Test Frequency Test Period in Years from Date of Installation
2.5
4.5
6.0
7.5 and every 1.5 years thereafter

3.3.6 X-ray testing of areas not suitable for NDT

X-ray non-destructive testing may be used to locate broken wires at termination areas and other areas where more conventional means of non-destructive testing is not possible, however this method of testing may not identify all the broken wires that may actually be present if the termination device is removed and the individual wires are examined. Experience with dragline boom suspension ropes indicates that 30 to 50% more wires may be broken when physically examined as compared to x-ray examinations (occasionally up to 66%). This significant difference is contributed to by “shadowing” of one wire behind the other so adjacent breaks may not be seen. The tested ropes are 83mm (3.25 inch) Bridgestand Construction, failures normally start in the 3rd layer and progress to the core.

Any broken wires in close proximity to termination points should be fully analysed for their effect on the continued safe operation of the rope and monitored regularly for further deterioration.

4 Examination

4.1 Regulatory Requirements

4.1.1 The examination at intervals not exceeding 24 hours of the external parts of any winding and rope haulage apparatus (including any ancillary thereto) which is in use for transporting persons through any shaft or roadway. Reference is made to R18.(a).

- 4.1.2 The examination of every rope used in a system for transporting persons through a shaft or roadway at intervals not exceeding 28 days. Reference is made to R18.(b).
- 4.1.3 The thorough cleaning (reference is made to R18.(c)), in the course of an examination referred to in 4.1.2 of every rope at the following places:-
- a) At all places liable to deterioration;
 - b) In the case of shaft winding rope - at places not more than 100 metres apart;
 - c) In the case of any other rope - should be not more than 300 metres apart.
- 4.1.4 The examination, on the cleaning of a rope as referred to in 4.1.3, of the circumference and surface condition of the rope and for any wire fractures. Reference is made to R18.(d).
- 4.1.5 The regular inspection of other ropes used in winding or haulage apparatus at such places on the ropes and at such times as the manager of the mine may nominate (should be nominated in writing). Reference is made to R18.(e).
- 4.1.6 The lubrication or dressing of ropes used in systems for transporting persons. Reference is made to R18.(f).

4.2 Visual Examinations - Guidance Notes

- 4.2.1 The mine management plan should include identification of the requirements for the extent and documentation of all examinations.
- 4.2.2 Visual examinations shall be conducted by a person having the appropriate experience, knowledge and information for the extent of the examination to be conducted. The suitability of the examining person should be to the satisfaction of the employer of that person and/or the Manager of the mine or his delegate. In general it would be expected that a "competent person" (as per definitions) may conduct visual examinations.
- 4.2.3 Safe access to the wire rope for cleaning, close examination and measurement needs to be provided.
- 4.2.4 Adequate lighting needs to be provided, a cap lamp may not be suitable for some examinations.
- 4.2.5 Areas to be visually examined should include the following:-
- a) All areas not examined by non-destructive testing
 - b) All areas having anomalies, including those previously detected by NDT methods
 - c) Areas in close proximity to anchor points/attachments

- d) Where the rope rests on any sheaves
- e) Corrosion prone areas. This may be dependant on:-
 - ventilation flow direction
 - water ingress
 - location in shaft
 - difference in strata composition which may effect water chemistry locally
- f) On all drum winders where:-
 - the rope cross over points occur
 - where changes in rope layers occur
 - where the rope leaves the drum at the conveyance park/docking positions.
- g) On friction winders where:-
 - the rope leaves the drum at docking positions
 - the loop formed at the bottom of the balance ropes for the docking positions.
- h) On drift winders where:-
 - the rope length moves sideways when the conveyance goes around a rail turn.
 - the rope from the attachment to within 100 metres of the conveyance.

4.3 Details and Records of Visual Examination as required by Clause 4.1.2 should include:-

- a) date of examination
- b) Broken wires. Record sufficient details to identify compliance with discard criteria as detailed in Clause 5 including:-
 - the number of wire breaks per lay length that occur in a strand, and the location of the lay length with the greatest number of wire breaks;
 - the greatest number of wire breaks per lay length that occur in the rope, and the location of the lay length;
 - the total number of wire breaks in the rope (refer Appendix F);
 - details of broken wires near any termination point; and
 - rate of increase of broken wires.

- c) **Wear** Note the location and extent of wear over the circumference of the rope and measure the remaining wire width of individual wires at the point of heaviest wear, using a monocular microscope with graduations or a similar device capable of measuring linear and depth dimensions. Use calculation to determine the remaining wire diameter and the degree of wear of the individual wires.
- d) **Corrosion** As far as possible, locate any corrosion on the rope surface or in the rope valleys, ascertain the extent of any corrosion on the surface of the rope and record the degree of pitting on the wire surface as compared to its diameter.
In particular any corrosion that has resulted in loosening of the outer wires should be recorded.
- e) **Change in rope diameter** Measure the rope diameter and where possible identify the cause of any change as compared to a reference position.
- f) **Change in lay length** Measure the lay length and where possible identify the cause of any change as compared to a reference position.
- g) **Distortion** Identify the type of any distortion (eg bird cage, kink, severe bend, strand or core protrusion, slack strands, waviness) and describe its severity.
- h) **Miscellaneous** Miscellaneous anomalies include core splices, result of lightning strikes and combinations of the above anomalies that result in damage or change to the rope structure.
- i) Identification and signature of examiner.

4.4 Measuring the diameter of wire rope. The diameter of rope should be measured by a suitable device such as rope or vernier callipers, with measurements made on a straight portion of the rope over the crowns of strands (ie not over the 'flats' of strands).

Each measured diameter should be the average of four readings. These readings should be in two pairs with the pairs separated by a distance of not less than 1.0m along the length of the rope but not more than 2 metres. The two readings in each pair should be at the same position along the rope but at not less than 60° to each other.

NOTE 1: Variation to the foregoing may be warranted for some installations but this should be justified by appropriate risk assessment and risk management processes.

NOTE 2: The location of diameter measurements should include the requirements of Clause 4.1.3 as well as include all other areas where significant deterioration has occurred or is likely.

4.5 Lubrication. Identify extent and effectiveness of lubrication.

4.6 Non-Destructive Testing - Guidance Notes

- 4.6.1 Non-destructive examinations shall be conducted by a competent person.
- 4.6.2 Safe access to the wire rope shall be provided.
- 4.6.3 Adequate lighting shall be provided.

4.6.4 The NDT instrument and associated accessories should comply with the following:-

- a) be suitable for environmental conditions in which it is to be used.
- b) be capable of operating in either direction of travel.
- c) be sufficiently sensitive to detect a change in metallic cross-sectional area of the rope of 0.5%.
- d) the instrument shall produce a signal with an amplitude that is readily discernible from the background noise, while it is passed over a broken outer wire having a gap between the ends of 1mm, in any rope construction and size in the range that is specified by the manufacturer. The detection of

the signal produced by the 1mm gap in an outer wire shall not be dependent on the location of the gap with respect to the sensing medium in the sensing head.

NOTE:- discerning broken wires from “background noise” may not be possible where heavy corrosion is present.

4.6.5 Length of wire rope to be NDT examined.

The choice of positions for the test equipment shall allow as much as possible of the rope in service to be tested. More than one test location may be needed, so that the full length of the rope may be covered. The rope between the following relevant positions should be tested as much as possible:

- a) For friction winder head and balance ropes between attachment and attachment, as close as practicable to each one. (refer Appendix G)
- b) For drum winders, between as close as practicable to the attachment and the rope's contact with the drum while the rope is fully extended down the shaft.

NOTE: Periodically at less frequency to normal NDT examination it may be appropriate to remove further rope layers from the drum for NDT examination to determine corrosion, fretting and cross over point deterioration, particularly for a rope that has been turned end for end or that is infrequently double reeved for heavy lifts.

- c) for static ropes, such as guide or rubbing ropes, over the full length.

4.6.6 Procedure for NDT.

The procedure should comply with the following:-

- equipment manufacturers operating instructions
- legislative requirements
- appropriate standards for the type of work being performed

4.6.7 Reference values of new rope.

After a newly installed rope has been bedded in, but before the rope has aged or deteriorated in any way, the rope shall be non-destructively tested and the rope diameter and the rope lay length measured at nominated locations for use in determining future deterioration from the established datum points. Some NDT instruments may be suitable for setting datum points from a new sample of rope cut from the new rope prior to installation.

4.6.8 Limitations of NDT.

Appendix H lists the many items that limit the ability and accuracy of NDT to measure and detect the many defects that may be present in a wire rope, hence NDT should not be the only means used to determine the suitability of wire ropes to remain in service.

4.6.9 Details and Record of NDE (Non Destructive Examination) should include:-

- a) Customer name
- b) Location
- c) Date of testing
- d) Date of issue of report
- e) Details and identification of rope tested, including reference to original test certificate.
- f) Date of rope installation
- g) Test report number
- h) Test method used
- i) Test equipment used
- j) NDT and visual inspection results see Clause 4.3 for visual inspection results and Appendix E, F and G for NDT examinations.
- k) Identity of the examiner, his signature on the report or that of an authorised signatory from his organisation on the report and his employer.
- l) Statement on rope condition with respect to the discard criteria given in this guideline, point by point.

NOTE: The method of classifying anomalies should be identified or alternately sufficient details of the anomalies should be provided.
- m) The rate of deterioration of the rope, incorporating the results of any previous relevant tests, in graphical form. A typical graphical report is shown in the Appendix F.
- n) Reference to this guideline

- o) A recommendation by the competent person that the period before the next NDE examination be reduced if it appears from the historical NDT records that the discard criteria condition may occur prior to the next normally scheduled NDT examination.
- p) A clear statement including a diagrammatic layout as detailed in Appendix G to identify the extent of the rope examined and not examined this should include the locations of the NDT instruments, sheaves, drums and conveyances
- q) Maximum loss of magnetic area relevant to the least deteriorated section of rope (the area used must be identified on the report)

NOTE: The test reports of any examination shall be retained until the rope is retired from service and for any additional period specified by the appropriate authority.

- r) any reason why NDT result may be unreliable eg severe corrosion masking local faults.
- s) Results of visual examinations as detailed in section 4.1, 4.2, 4.3 and 4.4.
- t) The person who conducts the NDT shall follow up his tests by conducting a visual examination of appropriate sections of the ropes which include in particular the areas identified by the NDT where deterioration may be present.

If the NDT competent person has any doubts about the continued compliance with this guideline then this doubt should be documented and a person more competent in the visual examination and evaluation of wire ropes should conduct a detailed examination and provide a statement, based on the contents of this guideline on the suitability of the wire rope for continued use.

- u) If anything is identified during inspection by a competent person that in the opinion of that person requires urgent corrective action, then this is to be communicated in writing to the most senior official at the mine before the competent person leaves the mine. It remains the responsibility of mine management to decide on the appropriate course of action.

4.7 Further Guidance Notes

4.7.1 Once deterioration of a rope is evident or the rope has reached the end of its life as per the Coal Mine Regulations all destructive tests should be accompanied by testing of a number of individual wires from a variety of rope samples. Tests should include torsion, wrap or bend and weight of zinc loss tests.

4.7.2 A comparison of the rope being examined in regard to results obtained from previous ropes should be made. Consideration should include the following factors:-

- a) any changes in winding cycle, tonnes raised or load per cycle.
- b) rope life.
- c) any destructive test results for previous ropes
- d) NDE test result data for the rope.
- e) breaking force as determined by destructive testing compared with indicated loss of metallic area
- f) Maintenance on rope drum and sheave groove profile/ tread diameter
- g) Records of monitoring of individual rope loads. (Multi-rope friction winders)

5 Discard Criteria

5.1 General

5.1.1 Ropes may deteriorate due to the cumulative effects of the following:-

- wear
- corrosion
- fatigue
- physical damage
- broken wires
- fretting
- overheating
- localised overheating
- lightning strikes

5.2 All of the discard criteria from Clauses 5.2 to 5.3 should be complied with:-

5.2.1 **Regulatory Discard Requirements:** These can be generally stated as necessary to ensure the rope factor of safety does not fall below that detailed in Section 2 and the following limits on service life for friction winders:

- a) **Head Ropes:** The period of service of any friction winder head rope shall not exceed 2 years unless extension of that time is granted by the Chief Inspector and it is subject to any conditions that The Chief Inspector may impose. Reference is made to R13.(1).

Balance Ropes: The period of service of any friction winder balance ropes at a mine shall not exceed 3 years unless extension of that time is granted by the Chief Inspector and it is used subject to any conditions that the Chief Inspector may impose. Reference is made to R14.(1).

5.2.2 **Further recommended discard criteria** The rope (being head, balance, guide and rubbing ropes used in friction winders and on drum winders) should be discarded if any one of the following occur:-

- a) Broken wires within one rope lay length visibly identified and or identified by NDT for:-
- Non-uniformly distributed broken wires causes a loss of rope metallic area of more than 5%. (ref 1.2.9)
 - Uniformly distributed broken wires causes a loss of rope metallic area of more than 8%

- b) Broken wires within any one strand lay length as visibly identified and or identified by NDT results in:-
- exceeds 15% of the total numbers of wires within any strand (ref 1.2.9)
 - the total number of broken wires in any strand is more than 40% of the total number of outer wires in the strand.

NOTE: filler wires are excluded from the latter because of their minimal contribution to breaking force.

- c) Broken Wires in adjacent lay lengths

The number of identified broken wires in five adjacent rope lay lengths is double that permitted for one rope lay length.

- d) Broken wires in valleys There is more than one visible broken wire within a rope lay due to in-service effects between strand-to-strand contact points in a rope valley.

Valley breaks are generally an indication of serious rope deterioration at strand-to-strand contact points and do not usually occur in isolation. (ref 1.2.9)

- e) more than one (1) broken wire is within 1 metre of any termination point as determined by visual or xray examination (NDT is often not suitable for examinations within 1 metre).
- f) The projected rate of deterioration due to the number of broken wires is such that excess loss of breaking force may occur before the next scheduled test.
- g) Outer wire wear Uniform wear of the outer wires over at least two rope lays has reduced the outer wire diameter by more than one third. Appendix C shows the effect on one type of rope construction.(ref 1.2.9)
- h) Rope diameter The rope diameter as determined in accordance with Clause 4.4 has been reduced by more than 6 percent, due to wear, core diameter reduction, core deterioration or corrosion. (ref 1.2.9)
- i) Loss of metallic area The loss of metallic area exceeds 6% unless a competent person recommends its continued use in writing. The loss of metallic area for ropes used to raise or lower conveyances used for transporting personnel shall never exceed 10%.

The maximum loss of metallic area for guide ropes may exceed 10% if recommended by a competent person and due consideration has been given to:-

- area of individual wires
 - potential for broken wires to catch at the guide contact point of the conveyance or counterweight
 - other discard criteria in this guideline
- j) Distortion If distortion of the rope structure, such as waviness or kinks, has occurred, the rope shall be replaced unless a competent person has advised that it is satisfactory for continued service (ref 1.2.9)
- k) Heat Damage The damage due to heat effects has resulted in pitting, distortion or any other signs of damage (ref 1.2.9)
- l) Corrosion Corrosion has caused significant pitting and loosening of the outer wires. (assess using one of the appropriate standards)
- m) Damage/Overload has occurred which may effect the ropes serviceability unless a competent person has recommended in writing that the rope is safe for continued use.
- n) Loss of original required rope breaking force as determined by estimation from non-destructive testing, visual examination, destructive testing and other appropriate means exceeds 10%. {Estimates of rope breaking force should be made by a competent person and supported by comparison of destructive testing and non-destructive testing for that rope construction, and that installation (Ref 1.2.9)}

It is to be noted that when using loss of cross sectional metallic area as a factor in deriving loss of breaking force then consideration should be given to the resolution length of the non-destructive testing machine. The shorter the resolution length of the non-destructive testing machine, the more accurately localised faults and changes in cross sectional area will be detected.

- o) Loss of breaking force as determined by destructive testing exceeds 10% of the original required breaking force or the rope no longer complies with the relevant factor of safety as Legislated, refer Section 2.
- p) Rope Stretch Excessive rope stretch or rapid increase in rope stretch that is detected by a rope management system, may be a reason for the rope to be discarded.
- q) When the elongation is reduced to less than 60% of original as obtained by destructive test

Any combined effect of the above is such that there is any doubt that the rope does not retain at least 90% of its originally required Breaking force or the rope no longer complies with the legislated factor of safety, or that this point could be reached before the next rope examination.

NOTE 1: Where a loss of breaking force is indicated by NDT, such a loss should be verified by a destructive test of that section of the rope after its removal.

NOTE 2: Rope manufacturers tables/information or appropriate standards should be consulted to identify the proportion of cross sectional area contributed by damaged outer wires. For locked coil ropes this may vary considerably.

5.3 Further Discard Information

5.3.1 Discard may be deferred if adequate information is available to ensure the factors of safety detailed in Section 2 are complied with and continued use is recommended by a competent person. Information should include comparison between destructive testing and non-destructive testing for the particular rope construction and installation characteristics. Appendix (D) and (E) list such a comparison between loss of area and rope strength for ropes used at a number of N.S.W. coal mines.

5.3.2 Corrosion is easily recognised when it occurs on the outside of a rope but when it occurs internally it is more dangerous because its extent can not be identified and it can result in:-

- a) tension failure which occurs when corrosion is severe and the remaining metal area is insufficient to support the load.
- b) corrosion fatigue which is the most common cause of rope failure and it occurs readily once corrosion is present, even slight corrosion can lead to fatigue, particularly if regular total loading is in the vicinity of one-quarter of the original breaking force of the rope but if corrosion is well defined fatigue failure may still occur at one-tenth of the original breaking force. (refer 1.2.11)
 - High tensile wires are more prone to failure by corrosion fatigue.
 - severe corrosion may cause decreased elasticity of the rope.

5.3.3 In cases of severe corrosion, loss in rope breaking force could exceed three times the % loss in metallic area (from Canadian research).

5.3.4 Fatigue Fractures When a wire is deteriorating due to fatigue it will show no visible signs of fatigue until it has undergone more than 90% of the loadings necessary to break it, then a small crack will appear on the surface of the wire.

The crack will probably go only part of the way across before the weakened wire snaps by bending.

If the fatigue fractures only occur on worn crowns then the fatigue may be due to surface embrittlement.

5.3.5 Further rope discard criteria information

Australian Standard AS 2759 (ref 1.2.5), AS1735.2 (ref 1.2) and ISO 4309 are useful for gaining an understanding of rope construction and deterioration. However whilst they include information regarding rope discard criteria it is not intended that this be utilised for mine winder ropes.

The following may be suitable for mine winder ropes:-

The "Ropemans Handbook", SABS 0293, BS 6570, and Australian Draft Standard DR 97350

5.3.6 Surface Embrittlement

When rope steel is heated above 700°C and is then suddenly cooled or quenched, the steel becomes very hard and brittle because it has changed to a "martensite" structure.

This can readily occur when the outer wires of the rope rub heavily on another surface causing the localised temperature rise which will be suddenly cooled as soon as the rubbing stops, the remainder of the wire below the rubbing surface taking the heat away. The martensite may only be 0.08mm (3 thousandths of an inch) and not detectable by eye.

Martensite can be suspected when wires break at worn crowns and at no other places and when wear is insufficient for the fractures to be explained by loss of metal and breaking force.

6 Application for Extension to Friction Winder Head and Balance Rope Life To The Chief Inspector of Coal Mines:

Applications shall be submitted by the manager and be accompanied by the following documentation:-

- 6.1 Statement from the Mine Mechanical Engineer in Charge that the rope is safe for continued use for a nominated period and complies with the requirements of this guideline.
- 6.2 Report from a competent person recommending the rope is in a safe condition for continued use for a nominated period should be provided. Such a report will include summaries of findings from statutory inspections as detailed in this guideline. If the metallic cross sectional area loss exceeds 6%, or any of the discard requirements are not complied with or the rope has been in service for longer than five (5) years then the competent person recommendation shall be required. This report shall include a statement with respect to the condition of the rope relative to this document, including in particular Sections 4.3 and 4.6.9.
- 6.3 Original factor of safety when newly installed, both actual and required.
- 6.4 Calculation of factor of safety if rope breaking force has reduced.

- 6.5 A graph of destructive test results Vs time together with destructive test load Vs elongation curve. As applicable.
- 6.6 Rope deterioration trend analysis including a graph of non destructive test results from the date of installation of the rope. Include identification if NDT metallic area loss is relative to new rope or not.
- 6.7 Length of time that the rope has been in service and the installation date.
- 6.8 Copy of full non - destructive test report, (refer Clause 4.6.9) which includes location of rope, rope construction details, test equipment used and statement with respect to condition of rope relative to this guideline.
- 6.9 Details of any changes to the operation of the winder which may have occurred since the rope was installed or other environmental factors.
- 6.10 Sketch to identify lengths of rope covered and not covered by NDT, to include principle dimensions, test station location, areas of historical problems, direction of ventilation, all sheaves - and comment on moisture in shaft.
- 6.11 History of rope test/ examination data correlated to breaking force of rope previously installed.
- 6.12 Maintenance data covering;
 - Rope groove/ tread diameter monitoring for rope drum and sheaves
 - Rope tension monitoring (multi-rope friction winders)
 - re-anchoring dates (all winders)
- 6.13 28 day, examination reports for the rope, covering the previous twelve (12) months of service.
- 6.14 The period of extension required

7 Records

The following records relating to each rope installation, shall be retained at the mine;

- 7.1 Rope specifications, rope load calculations and date of installation.
- 7.2 Reports of all Statutory examinations and inspections as required by the Scheme of Systematic examination for the mine.
- 7.3 Historical data for previously installed rope/s with comparisons to destructive testing of sections where NDT methods have identified anomalies or areas of significant deterioration.

- 7.4 Maintenance records for monitoring of rope drum/sheave groove or tread diameter, re-location of rope on the drum (putting spare rope into service to shift cross over points) rotation of guide or rubbing ropes to expose fresh rope surface to guides etc.
- 7.5 Dates on which the rope/s were capped and/or re-capped.
- 7.6 Copies of all NDT reports
- 7.7 Copies of all detailed visible examinations for the ropes in service.
- 7.8 Winding cycles achieved for each rope in the winding system and tonnage conveyed in the case of production winders.

3 Appendices

- A Friction Winder rope factor of safety formula
- B Typical friction winder rope factor of safety calculations
- C Example - Effect of external Wear on Rope Strength
- D Comparison - Loss of Metallic area to Strength.
- E Tables showing Area Loss and Local Faults - various rope installations.
- F Graphs showing area loss and local faults - various installations
- G Diagram of winding ropes examined by NDT etc.
- H Limitations of NDT Instruments

APPENDIX A

- 1 **Friction winder head rope factor of safety** - shall be calculated in two parts. Firstly the factor of safety (F) calculated as in 2.2 for the worst load condition. Secondly F_1 or F_2 shall be calculated for the rope(s) configuration when newly installed as detailed in clauses 1.1.1 and 1.1.2 respectively as shown in this Appendix.

When newly installed F shall be equal to or greater than F_1 or F_2 as applicable. For ropes other than newly installed refer to clause 2.3.2.

Refer to Appendix A for worked example.

- 1.1 Friction winder head rope (s) factor of safety .when newly installed shall not be less than the following:-

1.1.1 Personnel Transport F_1

$$4.5(R+C)$$

$$\text{Where } F_1 = 1.0 + \frac{\quad}{R(1+0.0051 L^{0.5}) - 13.5}$$

Where

- F_1 = Factor of safety (personnel)
 F_2 = Factor of safety (mineral or material)
P = Ratio of the diameter of the winding sheave to diameter of the winding rope
C = 35 where there is not a deflecting sheave or 43 where there is a nearby deflecting sheave.
L = Vertical distance in metres between the level of the top of the highest winding sheave and the level at which the winding ropes meet the suspension gear of the cage at its lowest position in the shaft.

1.1.2 Mineral or Material Transport F_2

For the purpose of the above the factor F_2 is defined as

$$F_2 = F_1 - 1.0$$

NOTE: this is equivalent to Notice D3 of the Mechanical Compendium - Notice to Mines and Manufacturers

APPENDIX B

**Example:- Friction Winder factor of Safety. Head Rope Calculation for New Ropes.
Friction Winder with 4 head ropes and 2 balance ropes.**

1. Actual Factor of Safety for the worst load condition.
The worst load condition occurs when the cage is located at the surface. Hence the following applies:-

Cage plus trailing cable	9550kg
Head rope attachment	544kg
Balance rope attachment	149kg
balance rope (480*88kg 2 ropes)	6374kg
80 men (80*88)	<u>7040kg</u>
TOTAL	23657kg
Load per head rope (23657 / 4)	5914.25kg
Force per head rope	58.02kN
Minimum breaking force(test certificate)	536kN
ACTUAL FACTOR OF SAFETY (F) (536 / 58.02)	9.24

2. To calculate F_1

$$F_1 = 1.0 + \frac{4.5(R+C)}{R(1+0.0051 L^{0.5}) - 13.5}$$

Where

$$\begin{aligned} R &= (\text{Winder Sheave Diameter} / \text{Rope Diameter}) \\ &= 2240/28 \\ &= 80 \\ C &= 35 \\ L &= 477.63\text{m} \end{aligned}$$

Thus

$$F_1 = 1.0 + \frac{4.5(80+35)}{80(1+0.0051*(477.63)^{0.5}) - 13.5}$$

$$F_1 = 7.86$$

$$9.24 > 7.86 \text{ OK}$$

As seen F is greater than or equal to F_1 and therefore the actual factor of safety complies with requirements of 2.3.1.

APPENDIX C

Example

Effect of external Wear on Rope Strength

The following is an extract from "Quantitative in service inspection of wire rope" by Herbert R. Weischedel as printed in Materials evaluation/46/March 1988.

"A rope of 6x7 fibre - core with external abrasion results in the loss of one third of the diameter of the outer wires, which translates into a 30% loss of metallic area (LMA) or a breaking strength loss for the outer wires. The wear equated to a 4.3% LMA for the entire rope.

The surface wires form a helix. As we proceed along the rope in the longitudinal direction, each surface wire of the strand will consecutively assume the position of the rope surface wires. Hence within a very short distance, well within the recovery distance, each strand surface wire will consequently suffer a 30% loss of cross section. Therefore, all 36 surface wires to the 6 strands contribute equally to the overall strength loss, not just the rope surface wires. Thus, the total **strength loss for this rope is 25.7%**, and the rope **should not be in service!**"

However consideration should take into account the fact that most ropes, when surface wear is present, are shown by experience to be worn predominantly in "patches" and on one side of the rope rather than uniformly around the circumference or periphery. It is not the intention of the guideline to force any rope into discard as a result of a few outer wires which may be worn such that the wire diameter is less than one third of the original and possibly offering no greater loss to the rope than a few broken wires. Hence a pragmatic approach is necessary when considering wear on outer wires.

APPENDIX (D)

**COMPARISON BETWEEN LOSS OF METALLIC AREA AND STRENGTH
AS
MEASURED BY NON - DESTRUCTIVE AND DESTRUCTIVE TESTING**

Example 1

WINDER	Vertical - friction winder
ROPE LOCATION	Head rope
ROPE CONSTRUCTION	28mm 6x12/12/9 g1770 fibre core, triangular strand, galvanised
ROPE SERVICE	5 Years
ROPE CONDITION	Some corrosion and pitting of surface wires evident at several sections of the rope, including within 1 meter of counterweight
MAXIMUM AREA LOSS	6.4% As measured by non - destructive testing
MAXIMUM STRENGTH LOSS	20% As measured by destructive testing

Example 2

WINDER	Vertical Friction Winder.
ROPE	Head Rope.
ROPE CONSTRUCTION	30mm 6*12/12/9 pre post formed RHLL
ROPE SERVICE	4 Years.
ROPE CONDITION	Some wear and indentations evident.
MAXIMUM AREA LOSS	16.5% as measured by non-destructive testing.
MAXIMUM STRENGTH LOSS	15.5% as measured by destructive testing.

Example 3

WINDER	Drift.
ROPE	Haulage.
ROPE CONSTRUCTION	27mm 6x7/3 FS B1770 RHLL.
ROPE SERVICE	10 MONTHS.
ROPE CONDITION	Medium external wear and corrosion and light internal wear and corrosion in inbye end, with worst area stated to be at a kink.
MAXIMUM AREA LOSS	7.2% as measured by non - destructive testing.
MAXIMUM STRENGTH LOSS	37% as measured by destructive testing 2 months after the above NDT was carried out.

Example 4 (see Rope No. E in Appendix E)

WINDER	Drift.
ROPE	Haulage.
ROPE CONSTRUCTION	38mm 6x23 (10/12/39) RHLL.
ROPE SERVICE	2.5 YEARS
ROPE CONDITION	Moderate wear with 28.5% wire diameter loss observed.
MAXIMUM AREA LOSS	18.5% as measured by non - destructive testing.
MAXIMUM STRENGTH LOSS	37.4% as measured by destructive testing 2 months after the above NDT was carried out.

APPENDIX E

ROPE LIFE PREDICTIONS BASED ON CORRELATIONS BETWEEN

NON-DESTRUCTIVE AND DESTRUCTIVE TESTING METHODS

Winder: Vertical - friction winder. Rope E: Drum (Drift)

Location of Ropes: Head.

Service Life of Ropes: 4.5 Years (approximately) Rope E: 2.5 Years (approximately)

Rope Identification	Rope No. A	Rope No. B	Rope No. C	Rope No. D	Rope No. E
Rope Construction	38mm - 6x25 (12/12/9) - Triangular Strand - Galvanised - R.H.L.L.	38mm - 6x25 (12/12/9) - Triangular Strand - Galvanised - L.H.L.L.	38mm - 6x25 (12/12/9) - Triangular Strand - Galvanised - R.H.L.L.	38mm - 6x25 (12/12/9) - Triangular Strand - Galvanised - L.H.L.L.	38mm - 6x23(10/12/39) Performed - R.H.L.L.
Maximum Area Loss	8.4%	7.4%	7.4%	7.4%	18.5%
Maximum Strength Loss*	10.0%	10.7%	9.0%	10.0%	37.4%
Local Fault Quantity	10	5	10	6	2
Rope Condition as determined by the three methods indicated	NDT: Slight corrosion and/or wear was indicated throughout, with a patch of heavy corrosion and/or wear. Visual: Slight to moderate surface corrosion pitting was observed. Destructive Test: Heavy internal corrosion pitting was observed during the destructive test examination.	NDT: Slight corrosion and/or wear was indicated throughout, with a patch of heavy corrosion and/or wear. Visual: Slight to moderate surface corrosion pitting was observed. Destructive Test: Heavy internal corrosion pitting was observed during the destructive test examination.	NDT: Slight corrosion and/or wear was indicated throughout, with a patch of moderate and heavy corrosion and/or wear. Visual: Slight to moderate surface corrosion pitting was observed. Destructive Test: Heavy internal corrosion pitting was observed during the destructive test examination.	NDT: Slight corrosion and/or wear was indicated throughout, with a patch of heavy corrosion and/or wear. Visual: Slight to moderate surface corrosion pitting was observed. Destructive Test: Heavy internal corrosion pitting was observed during the destructive test examination.	NDT: Severe corrosion and/or wear indicated over 90% of rope tested. Visual: Moderate wear with 28.5% wire diam. loss observed. Destructive Test: Severe corrosion and advanced wear observed during the destructive test examination.

* As determined by destructive testing of the rope sections which gave the maximum area loss during NDT (in this case also coincided with patches with detected heavy corrosion).

The correlations between destructive and non-destructive results, used in conjunction with the rate of deterioration charts if these ropes up to the point of discard, will provide a good basis for the prediction of the optimal lives of future sets of ropes used in this installation. As long as the progressive NDT results of these future sets of ropes, shown in chart form, follow similar trends to the retired ropes, then it can be expected that the rope should be retired when the loss of metallic area has reached a value of about 7%.

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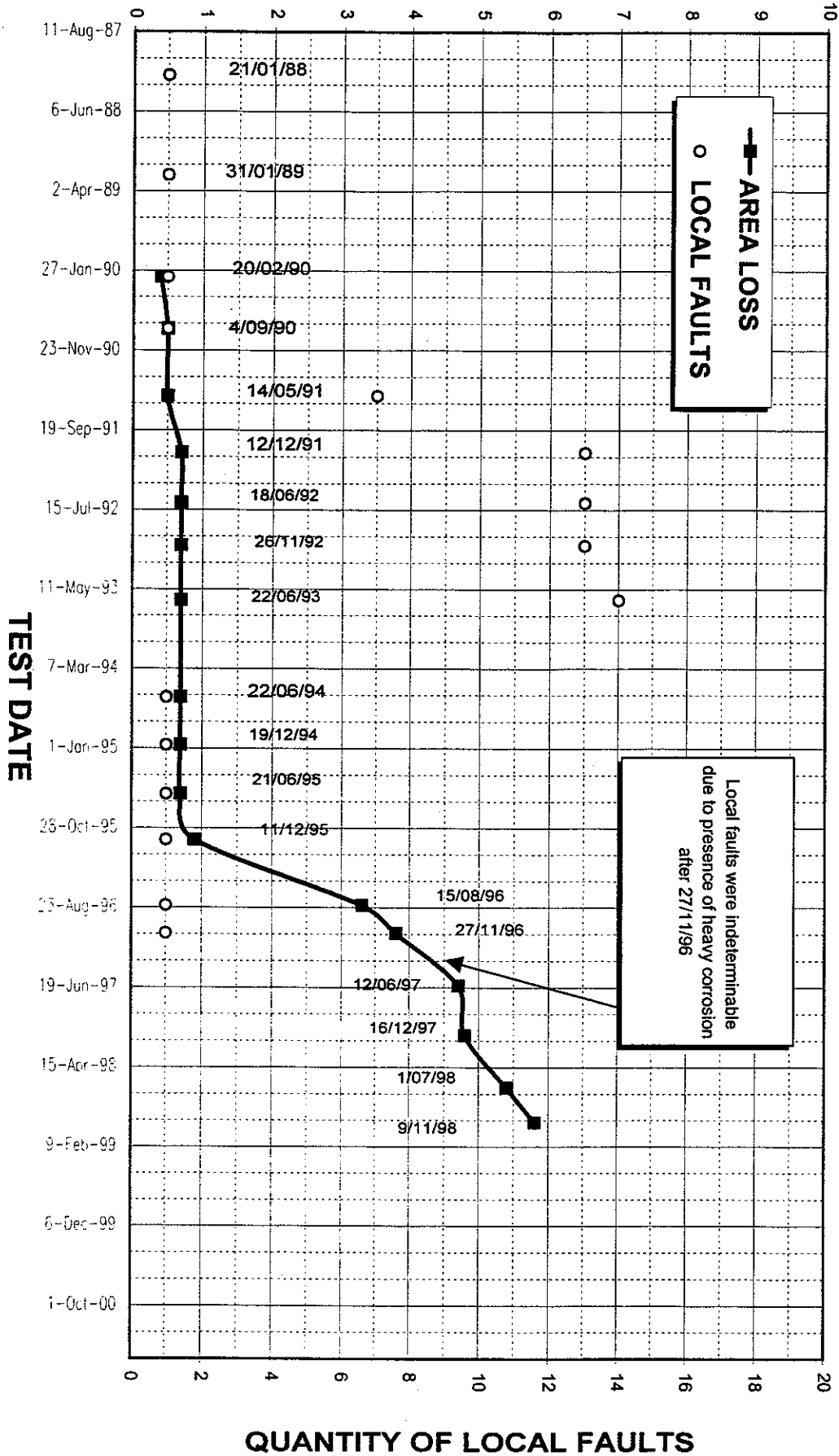
Approved by: B.R. McKenney

APPENDIX F

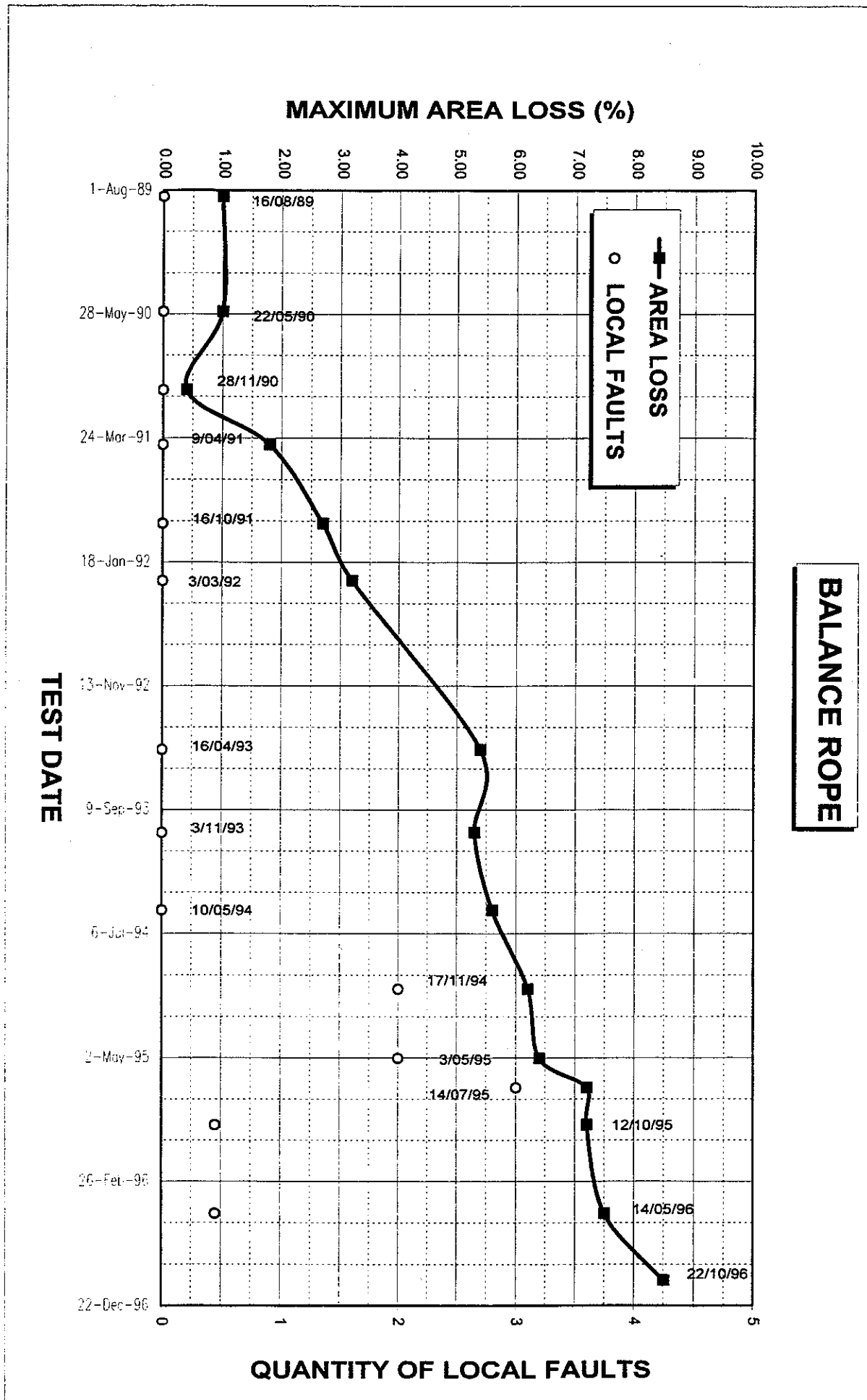
**GRAPHS SHOWING AREA LOSS
and
LOCAL FAULTS**

VARIOUS ROPE INSTALLATIONS

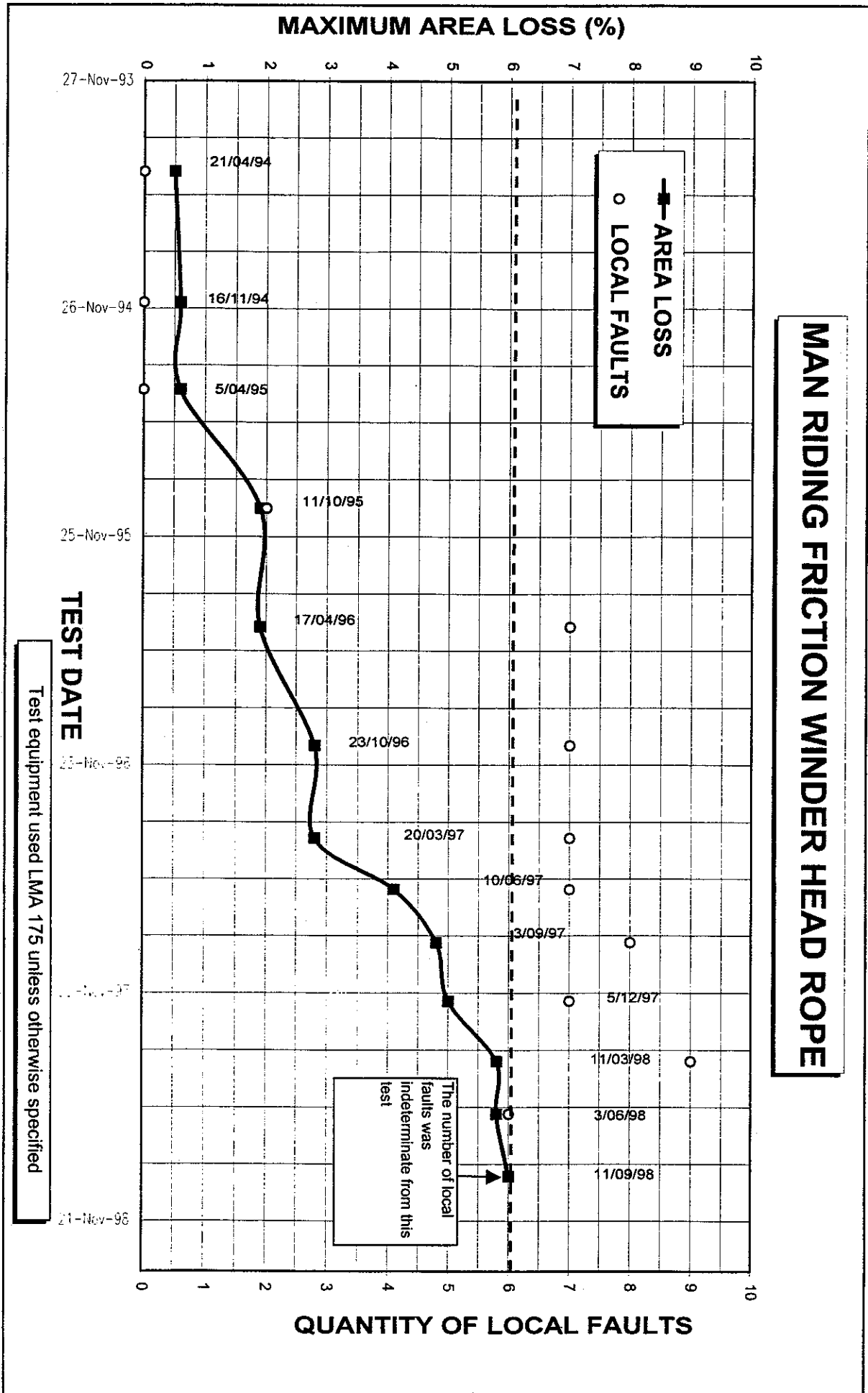
MAXIMUM AREA LOSS (%)



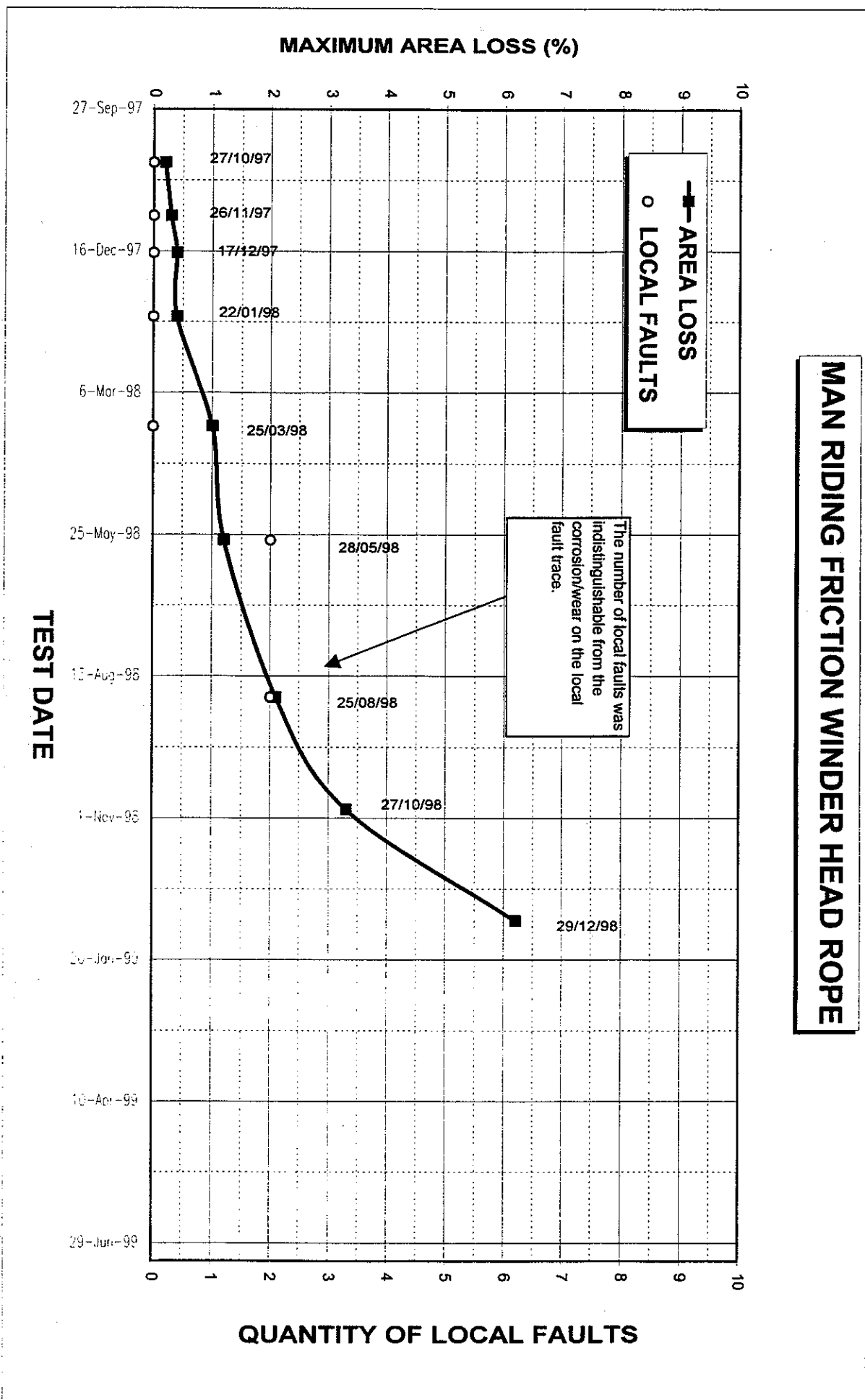
BALANCE ROPE

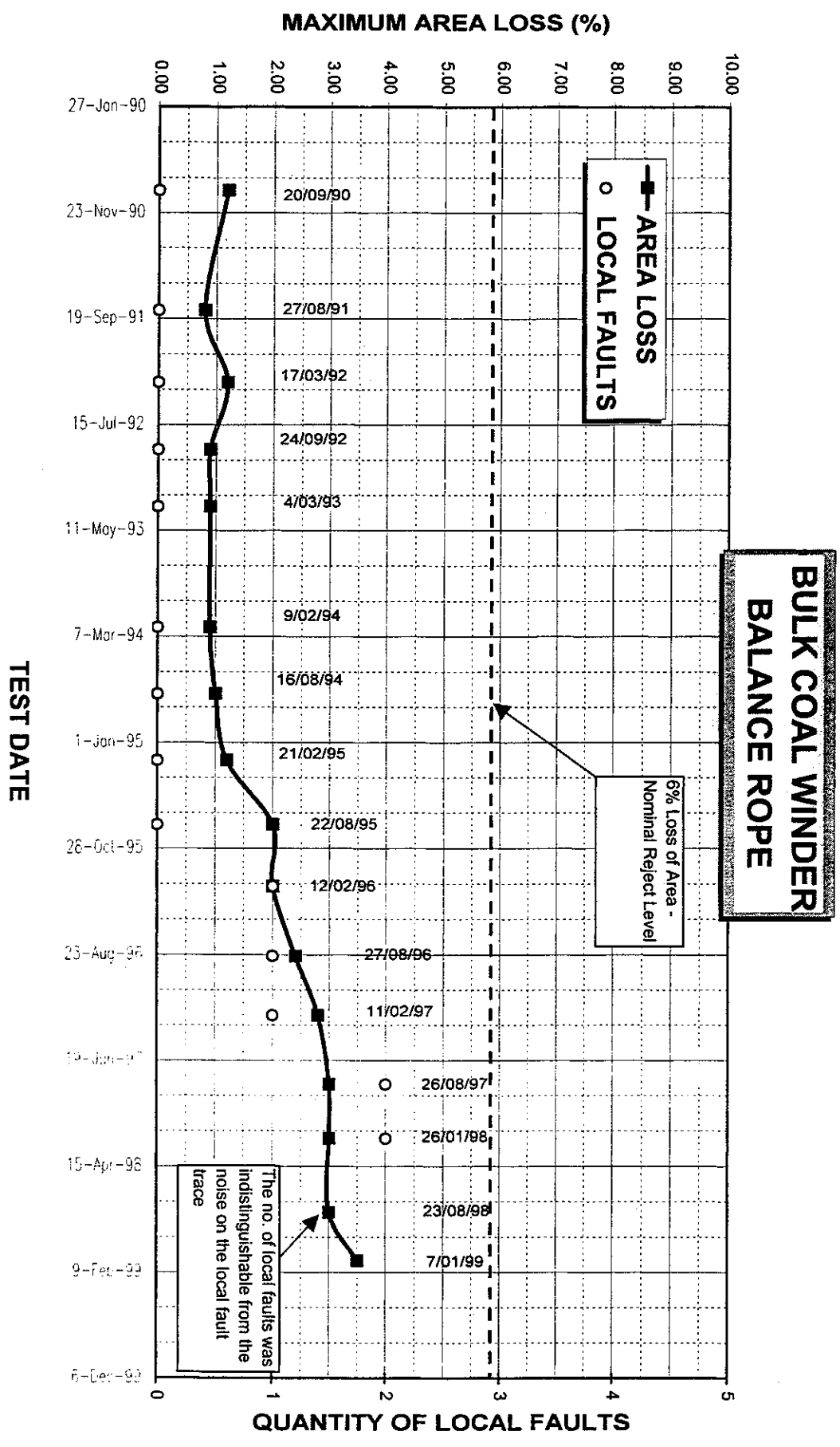


MAN RIDING FRICTION WINDER HEAD ROPE

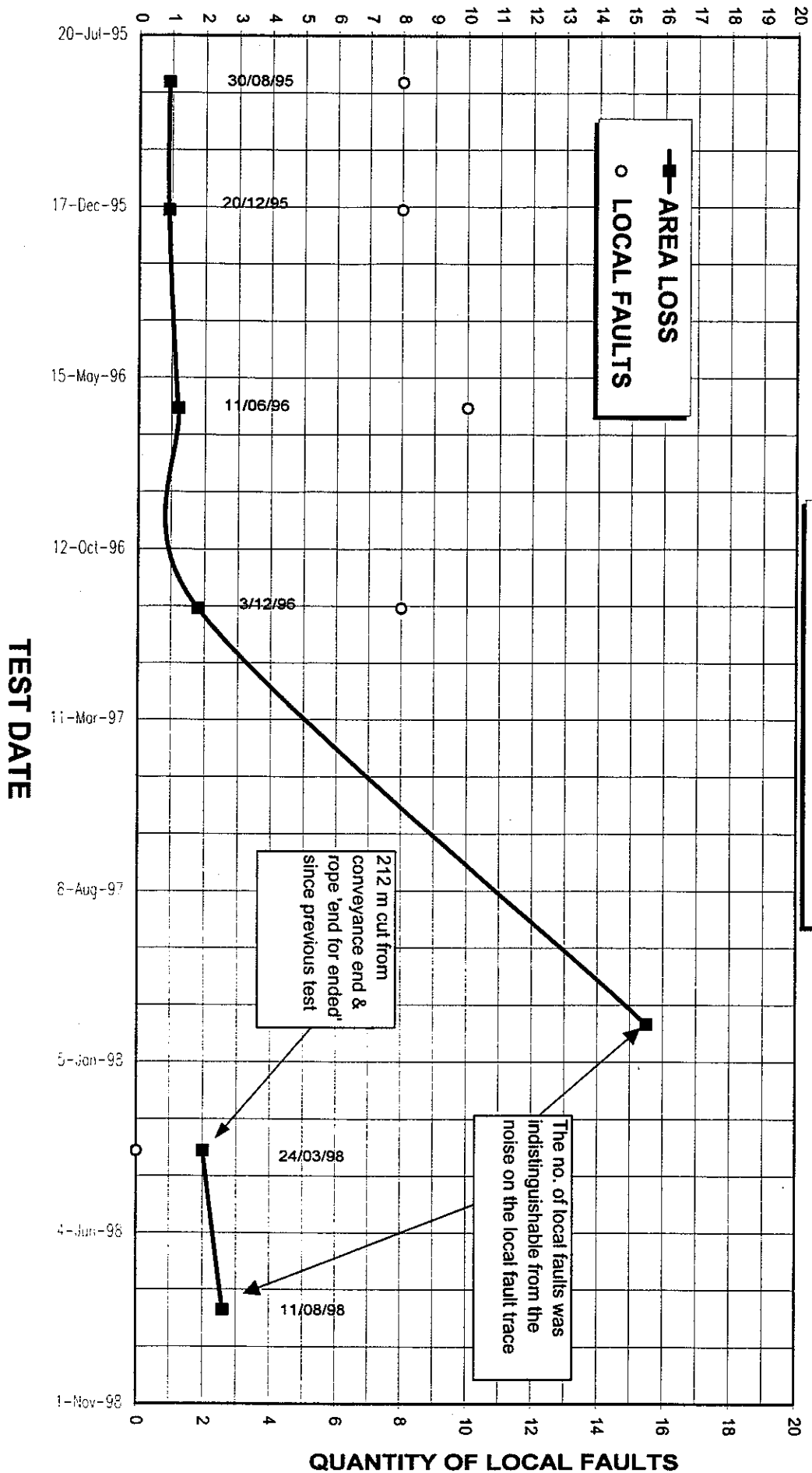


MAN RIDING FRICTION WINDER HEAD ROPE





MAXIMUM AREA LOSS (%)



APPENDIX G

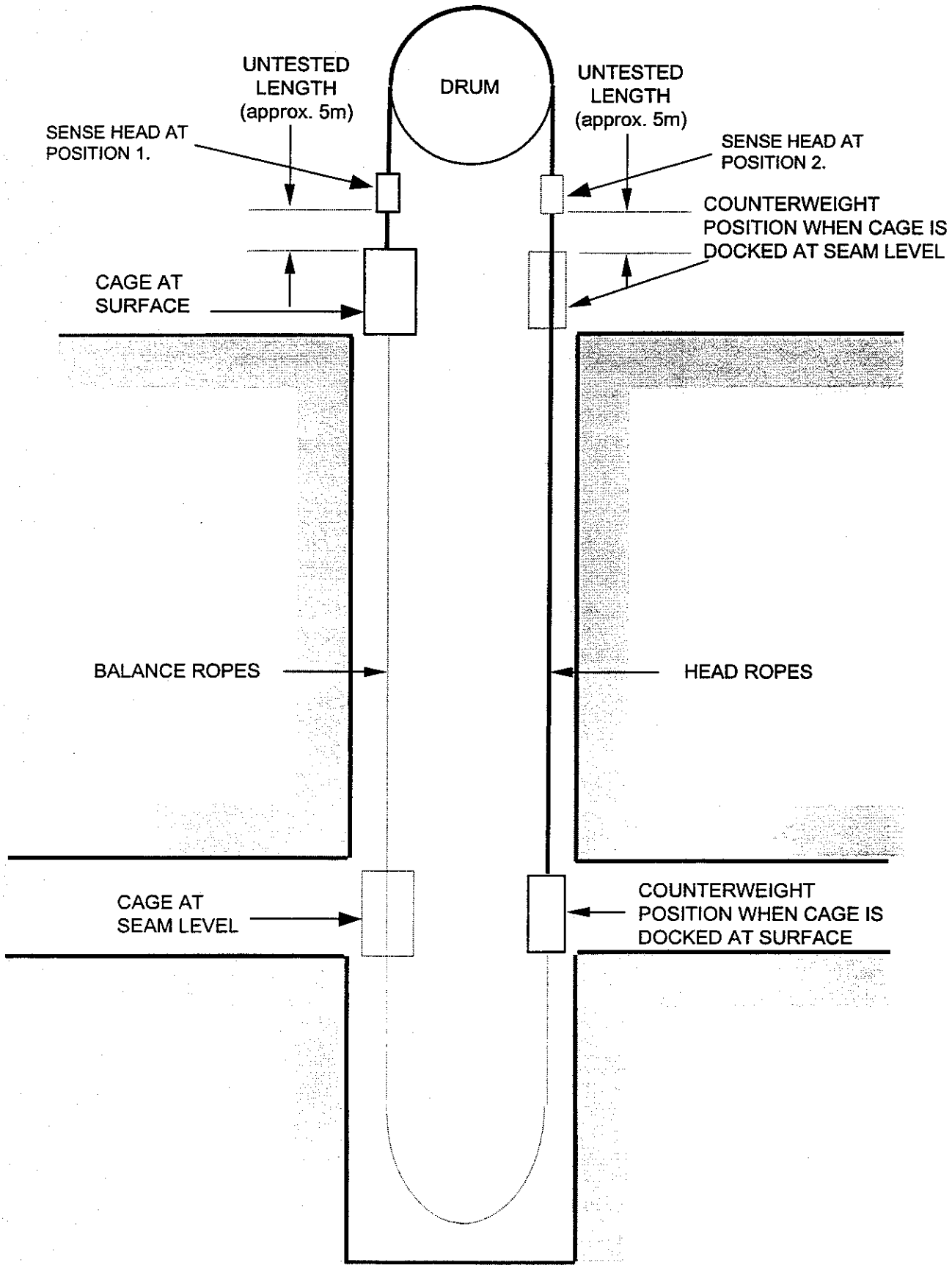
DIAGRAM OF WINDING ROPES EXAMINED BY NDT

34.1

FRICION WINDER

Head Ropes

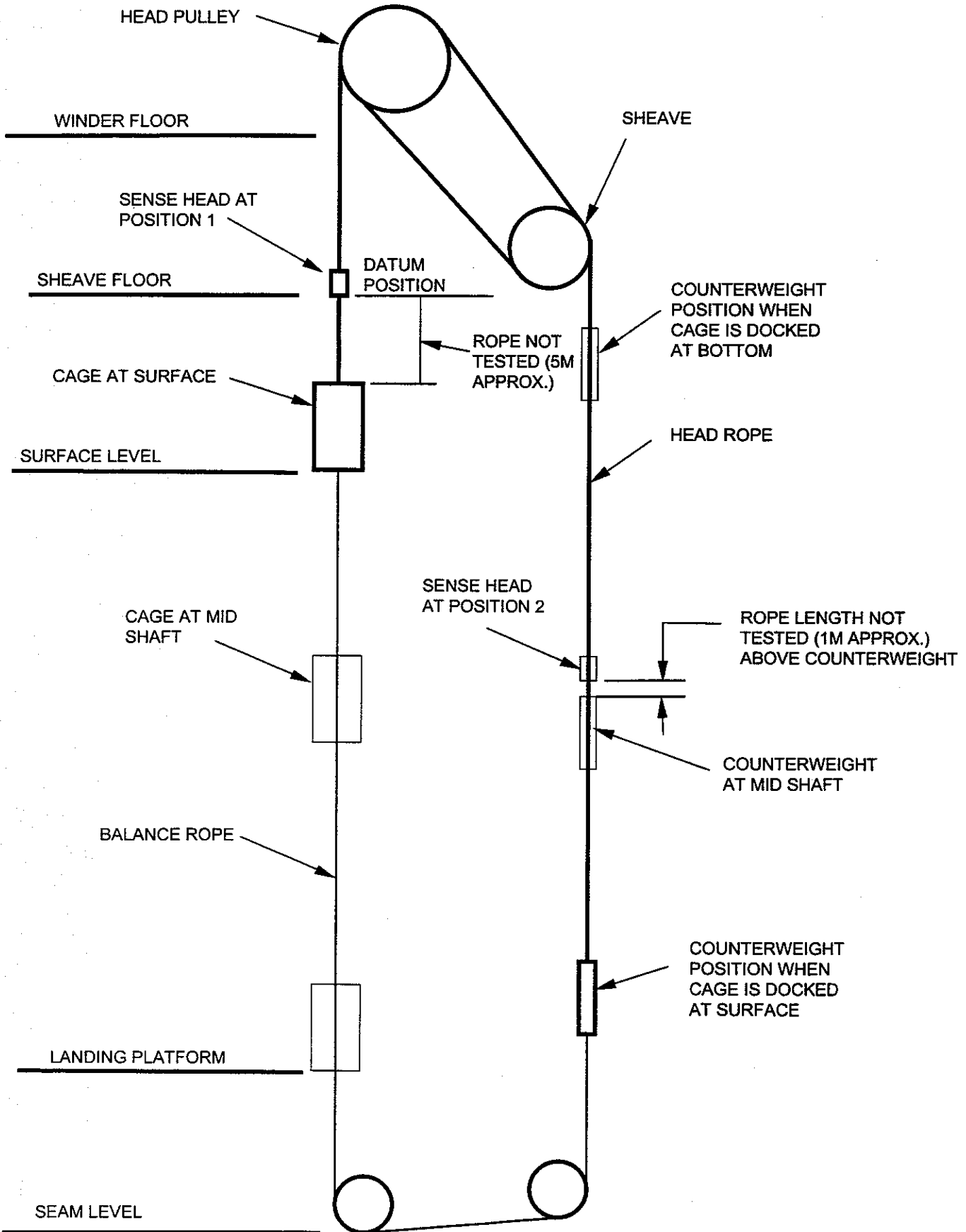
Fig. 1 - Rope Lengths Not Covered by NDT



368 942

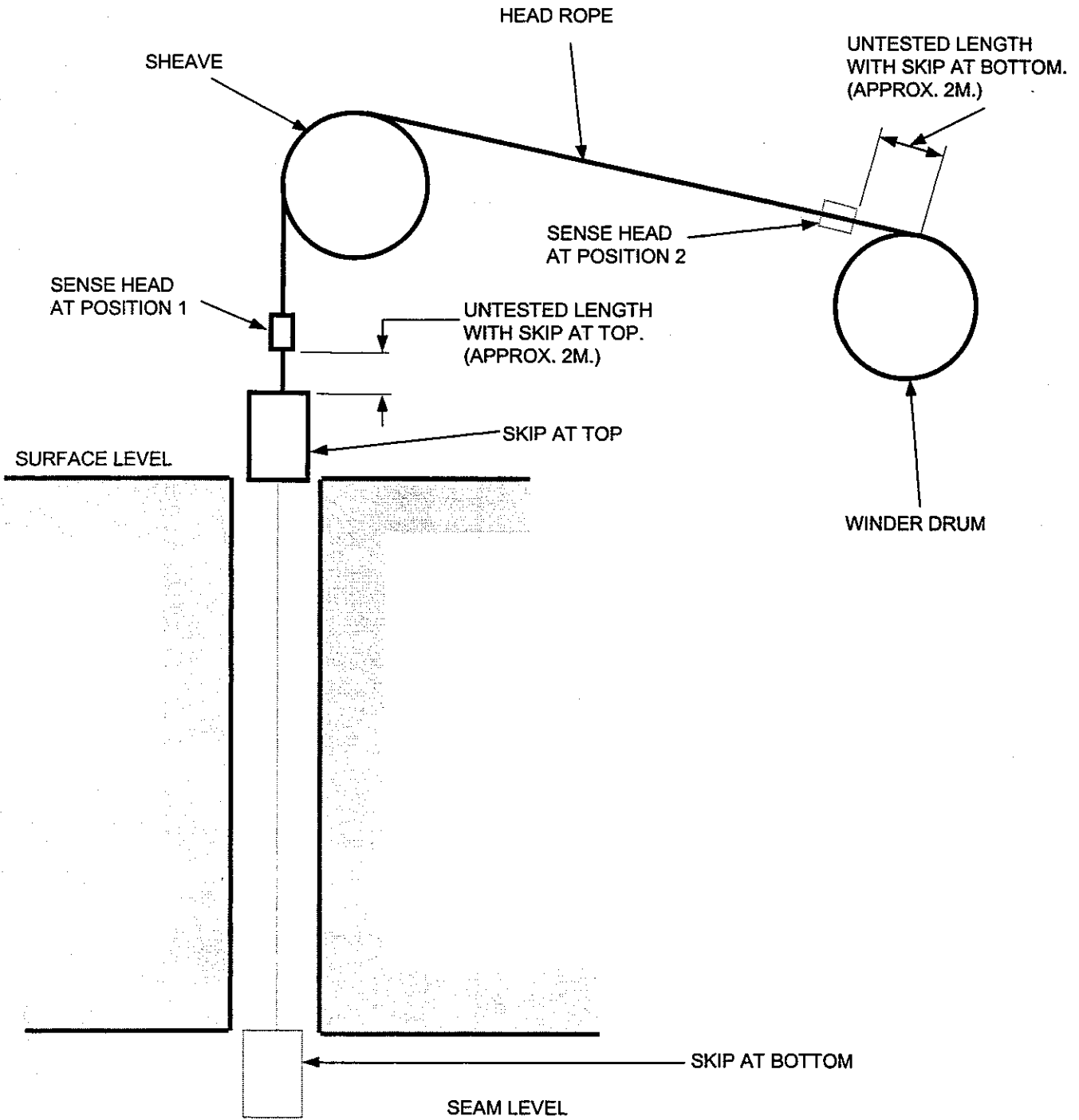
MAN RIDING SHAFT Head Ropes

Length of Rope Not Covered By NDT



HEAD ROPE

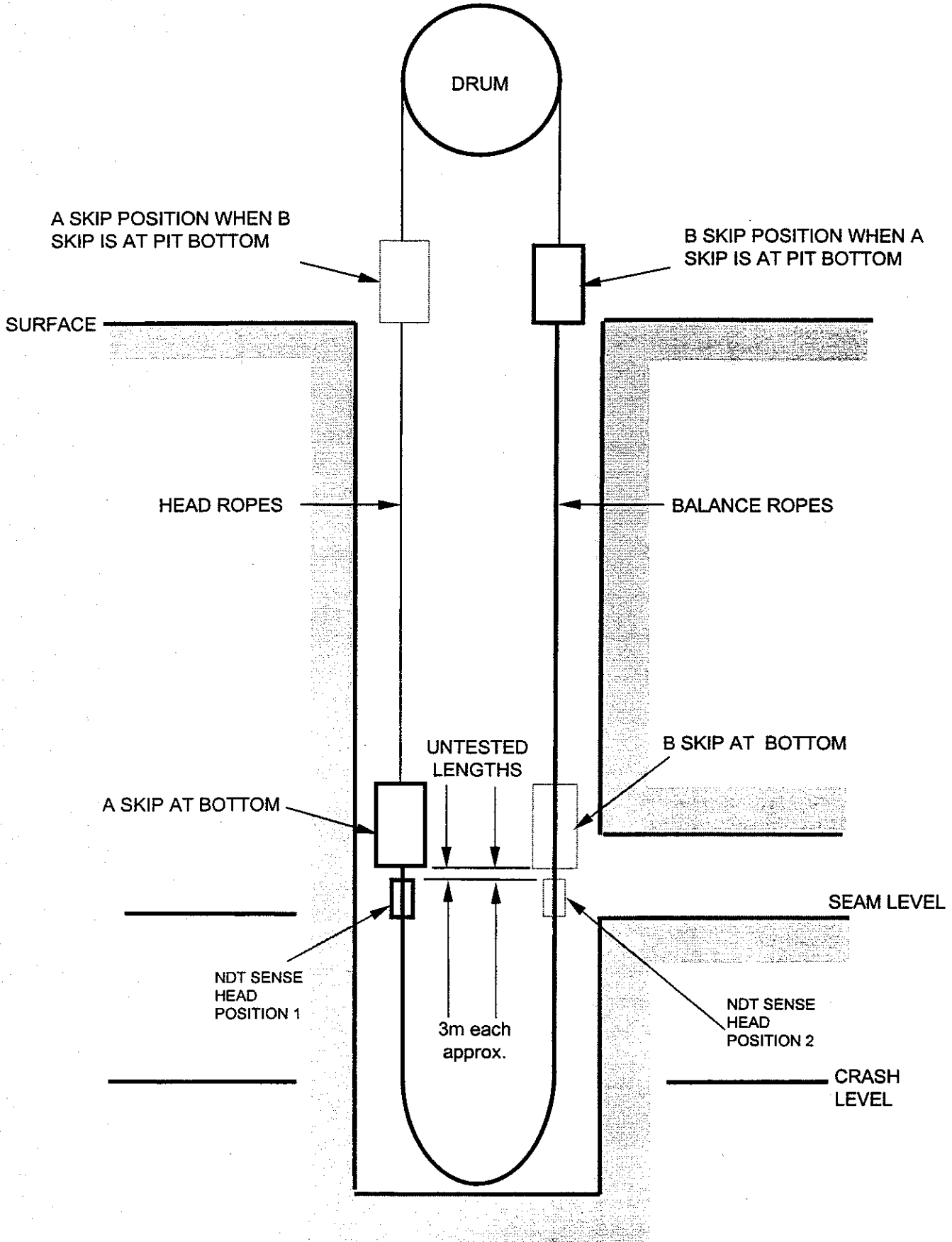
Length of rope not covered by non-destructive wire rope testing.



BULK COAL WINDER

Balance Ropes

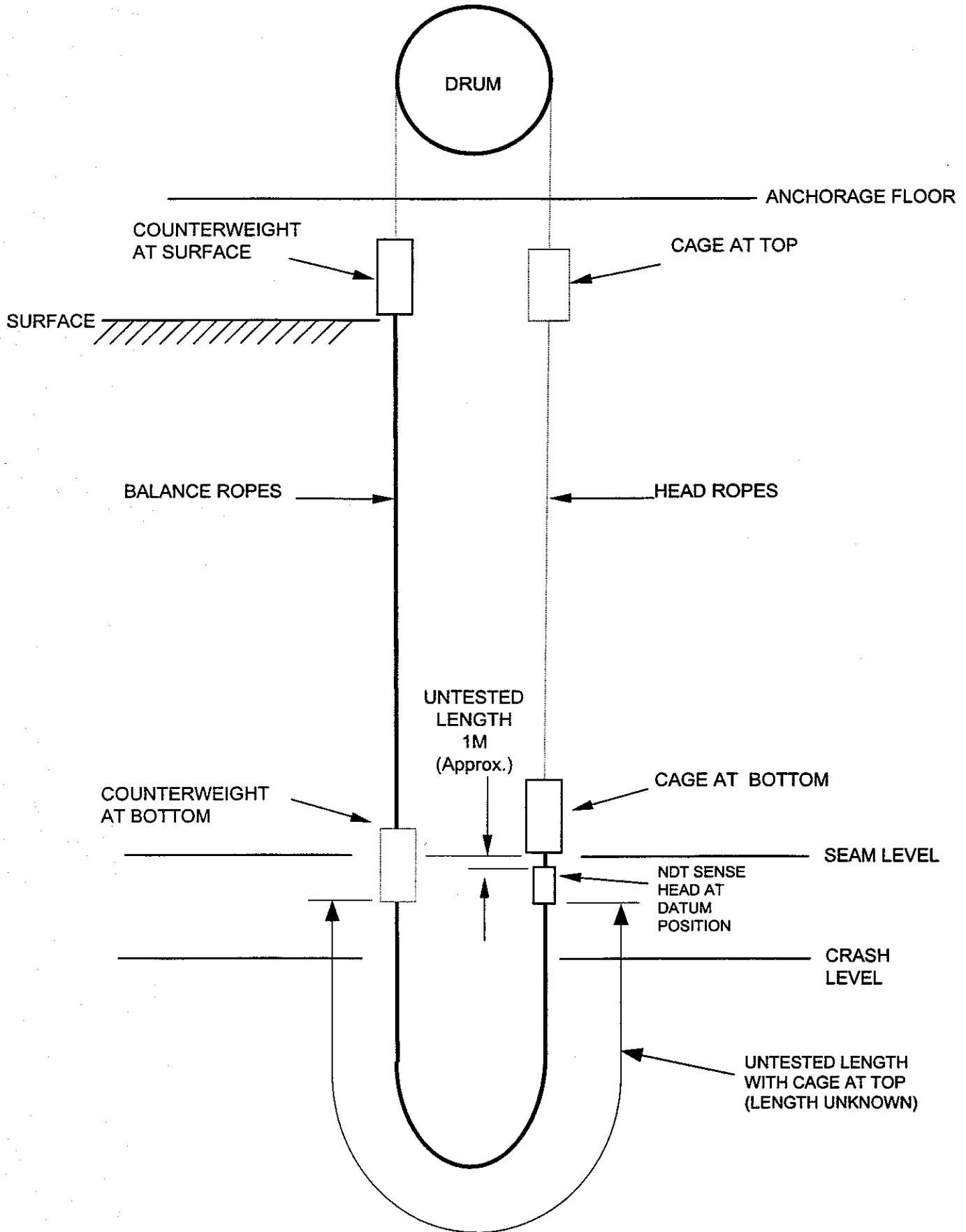
Lengths of Rope Not Covered by NDT



34.5

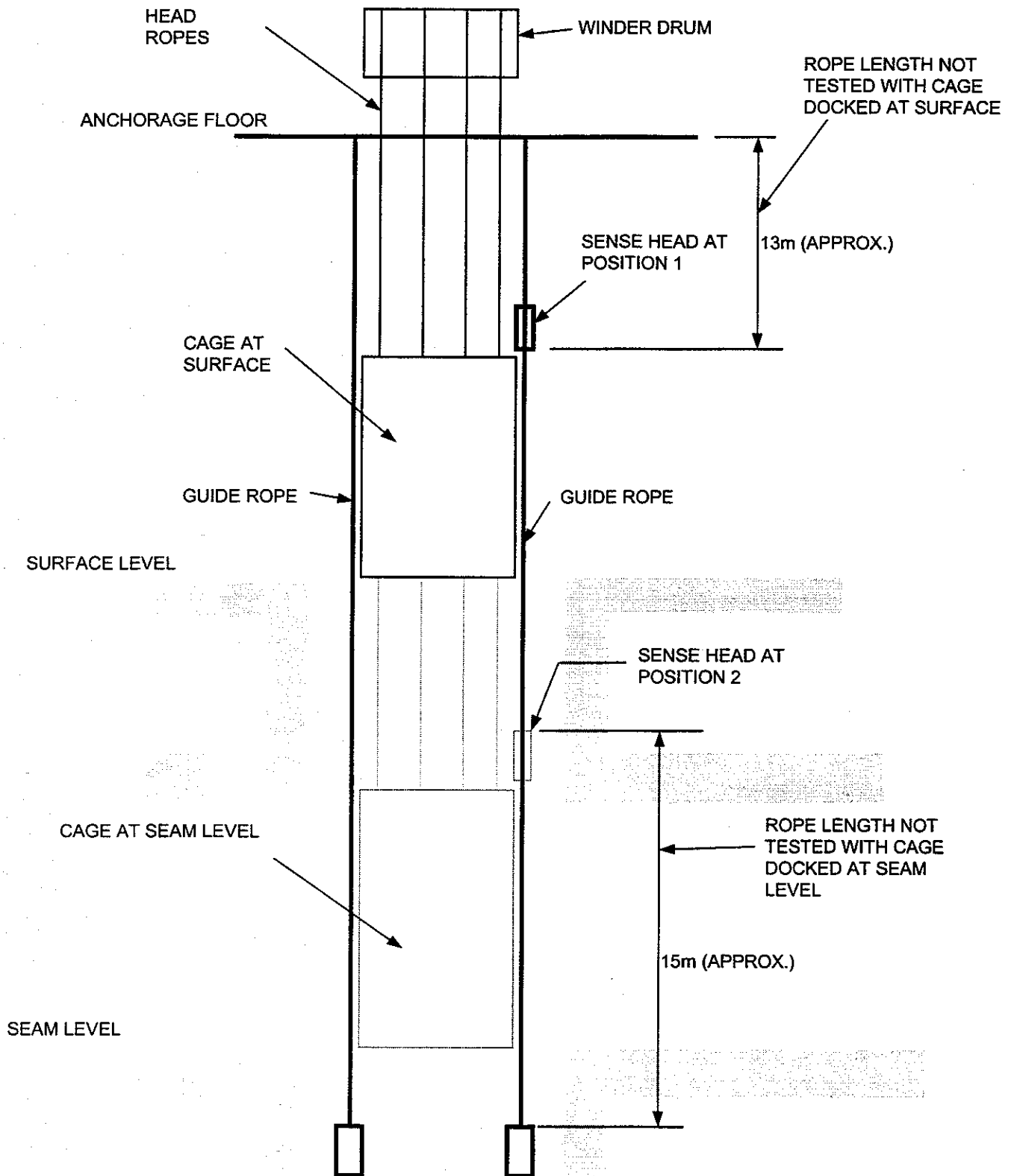
Balance Rope

Lengths of Rope Not Covered by NDT



Guide Ropes

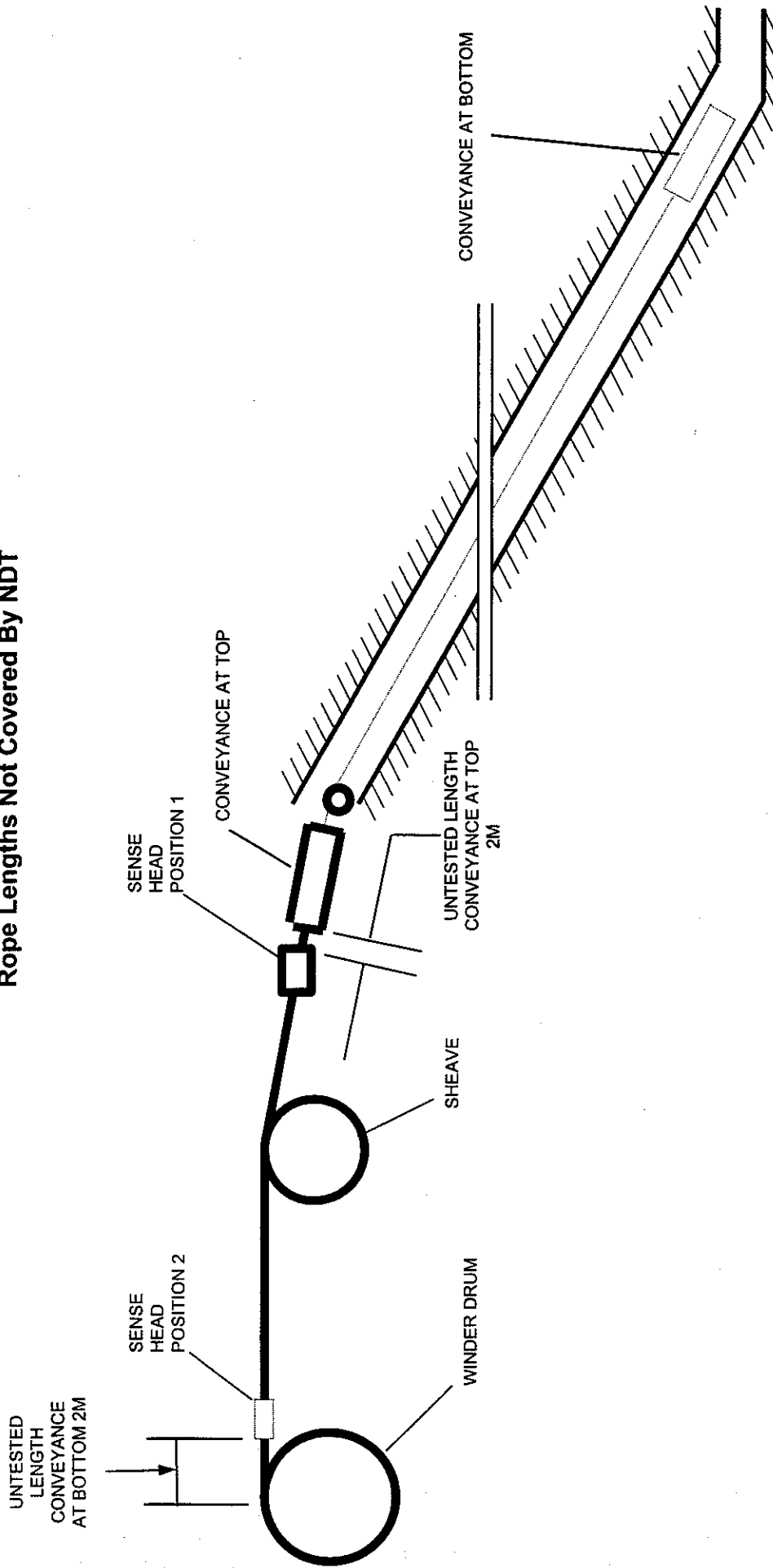
Lengths of Rope Not Covered by NDT (Not to Scale)



MEN AND MATERIALS DRIFT

Drift Rope

Rope Lengths Not Covered By NDT



APPENDIX H

Limitations of NDT Instruments to detect defects in wire ropes include the following:-

- 1 it can only be used for ferromagnetic ropes
- 2 It is difficult, if not impossible, to detect flaws at or near rope terminations and ferromagnetic steel connections.
- 3 Deterioration of a purely metallurgical nature (eg embrittlement, plastic deformation or fatigue) is not detectable until wires break.
- 4 The instrument is limited to rope speeds within the limits specified by the manufacturer.
- 5 The sensitivity of NDT method decreases with the depth of flaw from the surface of rope.
- 6 Signals due to the presence of corrosion in a rope may make individual anomalies/local faults indistinguishable.
- 7 Internal broken wires may not be detected, as an air gap is needed before NDT will indicate a break.
- 8 Measurements of changes in metallic cross-sectional area may be limited to showing comparative changes at various positions along the rope rather than the deterioration from the new rope.
- 9 Some rope constructions (eg full locked coil) may not be magnetically saturated by the NDT machine, especially if the diameter is near to the upper limit of the sensor head range. In such cases, the ability of the NDT machine to detect loss of metallic area (LMA) and local faults LF may be seriously impaired.
- 10 The site location of the NDT equipment which may result in interference from:-
 - 10.1 adjacent steel structures
 - 10.2 other wire ropes
 - 10.3 hand held radios, other electronic communication/devices including any ropes for transmitting communications in the shaft.
 - 10.4 powerlines, which may carry voltage spikes induced by control circuits.
 - 10.5 External electrical sources or magnetic fields may cause interference and hence effect the results.
- 11 The % loss of area as measured by NDT does not necessarily indicate % loss of rope breaking force.
- 12 Any relationship established between rope breaking force as established by destructive testing and NDT loss of metallic area may vary considerably so should not be totally relied on for identifying the remaining strength of a rope still in service. Extensive comparisons between NDT loss of metallic area and destructive testing can at least give some guidance.
 - 12.1 (Comments based on extensive testing in Canada)
- 13 Lack of experience/care/knowledge by operator.
- 14 Accuracy of NDT equipment
- 15 Type and size of faults in rope