Guidance on

Wire Rope Integrity Management for Vessels in the Offshore Industry

International Marine Contractors Association

www.imca-int.com

IMCA SEL 022, IMCA M 194

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IMCA promotes improvements in quality, health, safety, environmental and technical standards through the publication of information notes, codes of practice and by other appropriate means.

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- Training, Certification & Personnel Competence

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There are also four regional sections which facilitate work on issues affecting members in their local geographic area – Americas Deepwater, Asia-Pacific, Europe & Africa and Middle East & India.

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This guidance document has been developed by a cross-industry workgroup with input from various IMCA technical committees. It supersedes IMCA SEL 012 – *Guidance on the management of life cycle maintenance of non-man riding wire ropes* – published in December 2004, which is now withdrawn.

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Appendices

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Definitions

A&R	Abandonment and recovery
ABF/ABL	Actual breaking force. Actual breaking force is commonly referred to as actual breaking load (ABL). These two terms mean the same thing. The force (load) required to cause a wire rope to fail by fracture or distorting to such an extent that the load is released
API	American Petroleum Institute
ASTM	American Society for Testing of Materials
BS	British Standard
Class society	Organisations such as ABS, BV, DNV, Lloyd's Register, etc.
D/d	Ratio of sheave (drum, etc.) to wire rope diameter
EN	European Normalised Standard
Examiner	Person with the appropriate practical and theoretical knowledge and experience to detect defects or weaknesses in wire ropes and to assess their importance in relation to the safety and continued use of the wire rope
Fill factor	The measure of the metallic cross-section of a wire rope in comparison with the circumscribed area given by the rope's nominal diameter
Focal point	A suitable person (or body) appointed to collate, safeguard and disseminate all relevant information in order that adequate judgements can be reached
FoS	Factor of safety. Factor of safety values, i.e. the co-efficient of utilisation, can be found in codes such as DNV and Lloyd's Register and are based on the relationship between MBF and WLL/SWL
ICP	A competent person appointed by the company who is responsible for advising and operating the company's scheme of thorough examination. This may be contracted out to an external company, although it may be an in-house function if both impartiality and independence from line management can be demonstrated. The role may be undertaken by an individual or a corporate body where it is determined that the range of competencies cannot be demonstrated in one individual

Inspection	Visual checks carried out between thorough examinations and may be supplemented by a function check. These inspections are essential to ensure the integrity of the wire rope is maintained and appropriate remedial action(s) are undertaken as required
ISO	International Organization for Standardization
IWRC	Independent wire rope core. A central core made from steel wires arranged as an independent wire rope
LF	Local fault
LMA	Loss of metallic area
MBF/MBL	Minimum breaking force. Minimum breaking force is commonly referred to as minimum breaking load (MBL). The manufacturer guarantees that the wire rope will not break at a lesser value when new
NDE/NDT	Non-destructive examination. Also commonly referred to as non-destructive testing (NDT). For the purposes of wire ropes, NDE is usually taken to refer to a magnetic flux induction process utilised to determine loss of cross-sectional area or discontinuities such as broken wires
PMS	Planned maintenance system
PPE	Personal protective equipment
SANS	South African National Standards
Tensile test to destruction	The continued application of a load (force) to an item until the item fails by fracture or distortion to such an extent that the load is released. Destruction tests may be utilised to ensure the ultimate strength of a wire rope meets a required value
Thorough examination	Detailed appraisal (of a wire rope) conducted carefully and critically and, where appropriate, supplemented by NDE, testing etc. Thorough examination is a more rigorous process than inspection
WLL/SWL	Working load limit/Safe working load. Confusion exists between the terms 'working load limit' and 'safe working load'. WLL is the ultimate permissible load, assigned by the manufacturer of the item. The SWL may be the same as the WLL but may be a lower value assigned by an independent competent person taking account of particular service conditions
Working length	Working length consists of that length of wire rope planned to be used prior to the next thorough examination. Where a greater working length is subsequently foreseen prior to the next thorough examination, that further length should be thoroughly examined. The length for examination purposes will be working length plus three wraps
Wraps/layers	A wrap is a single turn of a wire rope round the circumference of a drum. A layer is a number of wraps covering the horizontal distance between the drum flanges
WSC	Wire strand core

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Introduction

This document provides guidance on the necessary elements of an integrity management system required to achieve an acceptable level of ongoing safety for the use of wire ropes in a marine environment. This guidance takes account of the range of environments including the sometimes harsh conditions experienced in the global marine environment and, for this reason, provides guidance which represents universal good practice.

A Wire Rope Integrity Management workgroup was formed from IMCA's Crane & Winch Operations Workgroup and other interests from the industry, including the European Federation of Steel Wire Rope Industries and the UK Health & Safety Executive. The work was overseen by the IMCA technical committees.

The development of this guidance has drawn on elements of what is considered current good practice from informed sources such as ISO 4309:2004, various company procedures, regulatory bodies and manufacturers' guidance. It has been developed to form a basis for industry good practice and to provide an auditable integrity management system. A list of relevant current standards at the time of publication can be found in Section 15 of this guidance. This guidance replaces IMCA SEL 012 – *Guidance on the management of life cycle maintenance of non-man riding wire ropes*, which is withdrawn.

None of the recommendations in this guidance are intended to conflict with or set aside any other recommendations, statutory or otherwise, which may relate to the inspection, maintenance and integrity management of wire ropes.

IMCA documentation is constantly subject to review and the secretariat would be interested in feedback regarding any improvements to the document, which can be e-mailed to imca@imca-int.com

2.1 Safety Note

The nature of a wire rope is such that there will always be residual energy stored when working with it. This introduces a range of potential safety issues including manual handling and unexpected release of energy. Risk assessments before wire rope thorough examination, maintenance, cutting or removal should take into account personnel safety. For example, removing wire ropes from drums can be hazardous. They can move violently and suddenly as they unwind from a reel and also when they are disconnected. Personnel working with or removing wire ropes from systems must also be alert to the potential for injury from broken wire ends.

As a wire rope ages, broken wires can start to appear, usually as a result of constant fatigue. These can be broken off to prevent them damaging the rest of the wire rope and indeed to prevent injury to handlers. It is usually best to bend them from side to side with pliers (not cutting through the wire) until they break off in the valleys between the outer strands of the wire rope. The position and details of the damage to the rope should be recorded (see Section 12).

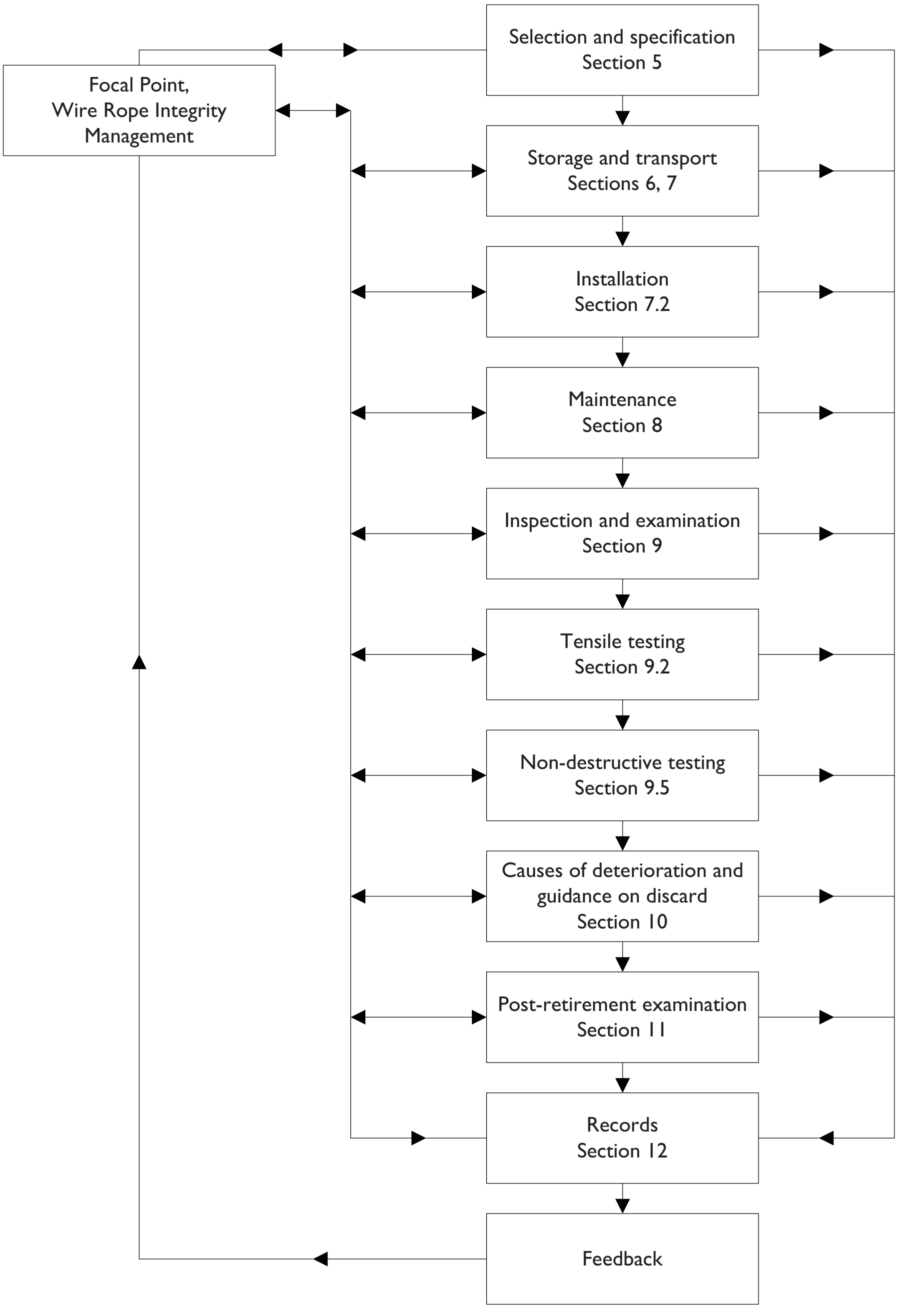

Figure 1 – Overview of a wire rope integrity management system

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Scope

This document provides guidance for the development of wire rope integrity management procedures for vessels in the marine industry. It includes guidance on selection of wire ropes, storage, transport, maintenance, description of the causes of wire rope deterioration, thorough examination, inspection, testing, discard criteria and documentation for wire ropes used by vessels in the marine industry.

The wire ropes covered by this guidance include, but are not limited to, crane ropes (but not standing rigging), pipelay equipment and diving bells.

This guidance does not cover general deck winch wire ropes, rigging, mooring, towing gear, anchor lines, lifeboat davits, overhead cranes and elevators. This list may not be exhaustive.

Note: If required, later revisions may include guidance appropriate to other wire ropes.

The flowchart on the opposite page underlines the importance of establishing and monitoring the integrity of a wire rope throughout its life. Note the relevance of the focal point, the controlling entity of a wire rope integrity management system. The focal point is defined as a suitable person (or body) appointed to collate, safeguard and disseminate all relevant information in order that adequate judgements can be reached.

The flowchart indicates that:

- each significant stage of its life cycle should be recorded;
- any irregularities, uncertainties or other important data should be fed back to the focal point for evaluation;
- the focal point ensures such communication;
- the focal point ensures that assistance and implementation of improvements is fed back to those involved with all stages of the wire rope's use;
- any changes should be recorded.

If, for example, a wire rope is delivered with unsatisfactory packaging, or if some deterioration is evident after storage, or damage noted or incurred during installation, such information, including that obtained post-discard, should be fed back to the focal point. Thorough examination of the discarded wire rope can provide essential evidence of deteriorating factors which have affected the wire rope in its operational role. This will be useful to those selecting the wire ropes and will help to improve the quality and effectiveness of wire ropes used for specific operations.

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Wire Rope Integrity Management and Associated Documentation

In order to provide robust and reliable evidence of the effectiveness of a wire rope integrity management system, it is imperative to maintain and retain close observations of each wire rope from selection to final discard. To achieve this, through-life documentation is essential.

The documented management of a wire rope including all the elements of this guidance, such as selection, certification, storage, thorough examination and inspection, history of use, records of damage or wear and final discard should be recorded. The format of the company wire rope integrity management system should provide ease of access to a wire rope's documented history. This could be, for example, by electronic means from a vessel or from a company's management system.

Whether individual vessels conduct their own wire rope integrity management system or there is a centralised company wire rope integrity management system, there would be distinct advantage in collating intelligence from the records of different wire rope usage throughout a fleet. To a degree, this should assist and improve understanding and future prediction of wire rope wear and suitability for a specific operation.

The following five tools can be utilised to provide wire rope integrity assurance:

- automatic discard (replacement) after a set period, e.g. twelve months;
- thorough examination and inspection;
- non-destructive examination;
- destructive tensile testing; and
- a range of post-retirement activities which will provide feed-back into the integrity management system.

Some comparative aspects are shown in the table on page eight.

The combination of tools adopted will vary for different rope applications and at different times during the rope's life. A company's wire rope integrity management system should document, for each type of rope application, which tools are to be used and when.

Due to the diverse degradation mechanisms it is essential that users maintain the integrity of the wire ropes in use and advise the focal point in their own organisation about any changes in use.

Information about damage to, and failures of, wire ropes or noted advantage (e.g. due to use of a particular construction for a specific application) should be distributed appropriately.

Wire rope integrity management should comprise a live system in respect of the full life cycle of the wire ropes, constantly being reviewed and updated and having ease of reference.

Although most vessels will have a significant number of wire ropes to manage, the benefits obtained from collating information and demonstrating the integrity of appropriate wire ropes used will provide effective assurance of the safety of this vital aspect of a lifting system.

Tools	Advantages	Disadvantages
Automatic periodic discard	◆ Cost-effective compared to other tools for low-value wire ropes ◆ Scheduling advantage	◆ Discarding wire rope which remains fit for further service
Thorough examination and inspection	◆ Primary integrity tool ◆ Principal means of locating mechanical damage/degradation ◆ Statutory requirement	◆ Difficult for examiner to retain focus on long length of wire rope ◆ Lack of 360° view or multiple examination runs required ◆ Visual examination is restricted to the outside of the wire rope ◆ Access to all parts of the wire rope not always possible ◆ Spooling requirements
NDE	◆ A screening tool to supplement visual inspection that identifies areas of the wire rope which require more detailed examination ◆ Indication of internal condition ◆ Permanent record ◆ Comparability of records	◆ Availability of experienced personnel ◆ Spooling requirements ◆ Not always logistically practicable ◆ Reliability depends on: – competency and experience of operator and analyst – suitability or performance limitations of equipment – access to all of the wire rope
Tensile testing	◆ Indication of residual strength ◆ Demonstrates maintenance of FoS ◆ Comparability of test bed results, year on year	◆ Accuracy/range of results ◆ Location of cutback not necessarily the weakest part of the wire rope ◆ Test sample preparation: – handling – serving – cutting – transportation – test bed availability and location
Post-retirement dismantling and condition checking	◆ Positive evidence of strength/condition when retired ◆ Scientific/repeatable/controlled conditions ◆ Numerous processes available ◆ May provide useful information for the selection of the most suitable wire ropes ◆ Builds up empirical evidence of effectiveness of integrity management system	◆ None

Table 1 – The integrity assurance toolbox

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Selection of Wire Rope

Wire rope manufacturers are often asked to provide guidance as to the expected life of their products; but such guidance, if offered, should not be construed as being a guarantee of wire rope performance. Conditions experienced in service are rarely matched by test conditions, on which such general guidance is usually based. It should be recognised that both methods of operation and wire rope constructions have become increasingly sophisticated over the years, demanding an even greater understanding and co-operation between wire rope manufacturer, designer of equipment and end user, particularly in respect of what is required from the wire rope.

Those involved with selection of a wire rope for any application, such as the engineers and project managers, need to assess wire rope requirements at an early stage in order to ensure compatibility of the wire rope and its associated system for its intended use.

When selecting a wire rope for a system, there are a number of aspects to consider. These include, but are not limited to:

- potential of block rotation/twisting and cabling (multi-fall) or rotation of load (single fall);
- loading regime (e.g. applied load range and frequency);
- wire rope torque effects (e.g. during installation);
- type of drum spooling, i.e. single or multi-layer and need for crush resistant wire rope to minimise cross-over zone and other drum related damage;
- diameter and tolerance of wire rope, adequacy of sheave and drum diameters (D/d);
- magnitude of fleet angle;
- need for fatigue resistant and wear resistant wire rope;
- unintended contact damage;
- environmental effects;
- swivels should be carefully considered before their inclusion in a system;
- termination – correct selection, maintenance, thorough examination;
- overhaul balls (headache balls).

There is a need for both manufacturer and end-user to fully understand both the requirements and the compatibility of the wire ropes available. Users should encourage manufacturers to provide the appropriate wire rope by early involvement, perhaps involving site visits.

The application and duty of the wire rope within the system should be discussed with the manufacturer by a competent person; this will allow the most suitable specification to be selected.

The considerations should include the arrangement of sheaves, drums and guidance systems to avoid damage to the wire rope in service, during installation and replacement. The method of installing and removing wire ropes should be considered to avoid damage or excessive deterioration of the wire rope. The spooling of wire ropes on to winch drums should be carefully controlled to ensure the correct back-tension and avoid contamination of the wire rope.

The minimum information to be exchanged with a manufacturer is below:

- rope duty;
- manufacturing standard, e.g. ISO, EN, API;
- wire rope designation;
- fill factor;
- nominal diameter and any specific tolerance requirements;
- wire rope construction;
- length (including sufficiency for wraps remaining on drum at full deployment);
- whether rotation-resistance is required;
- tensile grade;
- galvanised or ungalvanised;
- type and direction of lay;
- minimum breaking force (load);
- whether high frequency of bending cycles is envisaged, e.g. utilised in a heave compensated system;
- operating climate, e.g. high or low ambient temperatures;
- lubricant;
- maintenance lubrication requirements;
- storage and preservation;
- sheave/drum, etc. to nominal wire rope diameter ratio (D/d);
- wire rope terminations including SWL/WLL of end termination;
- whether any swivel connections are required (or should be avoided);
- details of drum grooving and the condition, shape and size of the grooves;
- whether subsea use envisaged; if so, depth and pressure;
- back tension required when spooling on to winch drum;
- drive systems including traction/linear winches;
- serving and additional instructions to ensure correct cutting and/or re-socketing of the wire rope and for when preparing wire rope samples for transportation and test;
- transport and storage packaging requirements;
- reel specification (e.g. back tension requirement, material, dimensions and lifting points);
- reel lifting details (including any special lifting accessories and/or equipment);
- the gross weight of the reel complete with wire rope, terminations, packaging and lifting accessories.

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Storage and Preservation

Storage is a vital part of preservation and the following should be addressed within the storage and preservation plan:

- reels to be clean, dry, well ventilated and covered;
- reels to be away from excessively high temperatures likely to dry the wire rope lubricant and away from any effects of welding/fabrication activities, chemicals, chemical fumes, steam or other corrosives;
- where reasonably practicable, reels of wire rope retained in storage for prolonged periods (particularly where this includes either storage during summer months or in a location with a high ambient temperature) should be regularly rotated (through 180° if possible) to redistribute lubricant which may otherwise drain towards the bottom of the reel. If the ambient temperature is 25°C or above, this operation should be conducted more frequently. Otherwise, reels should be rotated at least every six months;
- where open storage is inevitable, a waterproof covering should be arranged, using a breathable fabric to avoid humidity/condensation problems. The covering should prevent water ingress but should allow an airflow around the wire rope;
- manufacturers should supply details of suitable protective dressings that are available for storage purposes, that would be compatible with the lubricant used;
- periodic outer layer checks should be conducted to establish that no significant deterioration has occurred;
- wire ropes removed from storage should be thoroughly examined prior to being put into service;
- generally, stock should be controlled to facilitate the use of the oldest wire rope first.

Details of location, period, preservation (e.g. drum rotation, etc.) and conditions of storage should be recorded on the wire rope's documentation and should be maintained until the wire rope has been retired from service.


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Transport

7.1 General

During transport, the wire rope should continue to be cared for in the manner described in Section 6.

Care is needed to compensate for any expected environmental changes en route and to prevent physical damage to the wire rope.

7.2 Deployment to Work Site

Wire rope should only be deployed to the vessel or other work site when accompanied by its certification as described in Section 12.

Prior to deployment, the actual diameter of the wire rope should be measured and recorded.

- If the wire rope is to be taken from the storage reel and stowed on its working drum, correct working procedures are necessary to ensure that the wire rope is not damaged in the process.
- Lifting of reels can involve challenging issues and guidance should be sought from the relevant competent persons.
- Examine the working drum for wear and damage. To ensure that the wire rope specified at order stage is appropriate, the suitability of the groove contour should be checked prior to the installation of the wire rope.
- All sheaves and rollers that the wire rope will utilise should also be inspected to ensure good condition, correct operation of moving parts and ease of rotation of sheaves and rollers.
- Depending on the size and weight of wire rope, different methods will be used to rig or load the wire rope into its system. A suitably trained person should supervise the operation in accordance with company procedures. Any wire rope which is coiled or held on a reel contains significant stored energy. Safety is paramount with all wire rope operations – wire rope ends released from storage reels can move suddenly and violently, wire ropes secured to reels or shackled to equipment can have twists and retained torque in them which are not apparent until the wire rope is released. Large reels will have significant momentum once they start to revolve.
- If the wire rope reeving operation includes the need to pull the wire rope through with the use of another wire rope (messenger rope), some of the points that need to be addressed include:
  - Sometimes the only practical method is to use the old wire rope as the messenger rope. However, this has a number of disadvantages which should be taken into account. The old wire rope may induce torsion into the new wire rope and if this happens, the new wire rope will require any turn inadvertently induced to be removed before it is secured to the drum.

- The connection between the two wire ropes needs to be adequate for the forces induced. It should be able to withstand turning through the sheaves and bending around any rollers or negotiating any other directional changes and correctly sized and shaped to pass through all the throats and other possible choke points in the system.
- Rotation of the messenger wire rope should be avoided. Rotation resistant wire rope or three-strand fibre ropes may be more suited to this task.
- Wire rope socks ('Chinese fingers'/'snakes') can be used to connect wire ropes. Great care should be taken when any such attachment method is utilised. Use of a swivel connection is not advisable as it may induce the wire rope to unwind. It is essential that the correct manufacturer's instructions are followed at all times.
- The reel from which the wire rope is pulled should rotate in a controlled manner to avoid kinking and subsequent damage to the wire rope.
- The wire rope should be kept clean, clear of dirt and grit during installation and paid out within specified fleet angles. When wire ropes are being loaded on to their working drum, back tension should be applied to maintain uniform reeling on to the drum. Manufacturer's guidelines will usually indicate how much back tension should be applied. The required tension is often given as a percentage of the minimum breaking force (MBF/MBL) of the wire rope.

◆ The method of achieving the required back tension should relate to the application and the system concerned. The preferred option is to utilise equipment designed and constructed for the purpose. A risk assessment should be conducted prior to undertaking this type of activity. For heavy wire ropes or those being reeved into a system, sophisticated methods of applying the back tension are required utilising appropriate equipment, e.g. a diesel powered, deck mounted spooler.

◆ The wire rope should travel from top of reel to top of drum or from bottom of reel to bottom of drum to avoid reverse bending and putting a twist in the wire rope. Correct spooling of a wire rope on to a drum is essential. Loose or unevenly wound wire rope will be subject to crushing and distortion. The correct direction of coiling (from left or right side depending on the lay of the wire rope and whether under or over the barrel) is of critical importance on a plain barrel drum. Grooved barrels will assist the wire rope to wind on evenly but on a multi-layer drum it should be noted that the direction of coiling is reversed at every subsequent layer. Manufacturer's guidelines will usually give advice on the fleet angles required. However, as a general rule a fleet angle of 1.5° is recommended for a plain barrel and 2.5° for a grooved/Lebus barrel.

◆ The wire rope should be spooled on to the drum in a controlled manner. The condition should be constantly checked as it is spooled. Note: It may be appropriate to apply lubrication and carry out NDE at this stage.

◆ After the wire rope is installed, it is prudent to run through its cycle under a load of approximately 10% of SWL (unless otherwise specified by the manufacturer) at least once to remove residual turns. This should be carried out prior to use.

◆ During the post-installation period during which the wire rope is settling in (normally the first few weeks) systematic inspection is of particular importance and should be performed on a daily basis.

◆ If the wire rope has to be cut the correct procedures should be followed; ensure proper safety precautions are used (see section 9.3).

◆ Procedures followed for installation and other information such as lubrication and NDE results should be recorded.

8

Maintenance

8.1 Overview

This guidance does not cover aspects of the maintenance of winch machinery, control systems, sheaves, swivels, rollers or any other mechanical equipment or plant and other components of the wire rope system, but clearly their maintenance will affect the wire rope's safety and service life. Such issues should be covered by the company's PMS.

Good practice would require that the maintenance of the wire rope is specific to the particular operation, its use, its environment and the type of wire rope involved.

In practice, the difficulties of obtaining access to the entire length of a wire rope on a system may prevent the application of lubrication to the full length. Maintenance records should reflect the extent of lubrication, which should be a minimum of the working length plus three wraps.

Wire rope lubrication should be carried out periodically under a vessel's wire rope integrity management procedures, which should be part of a vessel's PMS.

8.2 Lubrication

The manufacturer should provide a wire rope that is lubricated properly for its expected use. This is only likely to last for a limited time in service, depending entirely on the use and environment that the wire rope is subjected to and exists within.

Unless otherwise indicated by the manufacturer, a good maintenance regime would ensure that the wire rope is, as appropriate, lubricated and covered with a service dressing, particularly on those lengths which pass through and around sheaves and/or are used subsea.

Maintenance should ensure continued lubrication as required and when pressure lubrication is not practicable or recommended, other methods should be used, such as spreading or brushing penetrating lubricant in accordance with manufacturer's recommendations.

Any lubrication and service dressing should be compatible with the original lubricant used by the wire rope manufacturer. Manufacturers should advise whether pressure lubrication is suitable for a specific wire or, if not, what method of lubrication and lubricant is recommended. Pressure lubrication needs to be carried out, with care, by operators trained in using the equipment.

If wire ropes are removed or shortened from drums for maintenance or testing purposes, it is important to re-spool them correctly (see Section 7.2). Also alarms, cut-outs and other control equipment will require to be reset and checked.

The ability to maintain the wire may be impacted by access to the wire rope and the system into which it is installed. Other relevant factors include but are not limited to the following:

- the length and diameter will affect the time required to carry out the maintenance, as will availability of access to all parts of the wire rope from suitable working areas;
- the environmental conditions that the wire rope will encounter will be a consideration when deciding the frequency of maintenance operations;
- the operating cycle and frequency of use.

The correct lubrication status of the wire rope should be maintained at all times. In the event that an area of the wire rope shows a lack of necessary lubrication, or that the lubrication status has unexpectedly deteriorated in some way, it should be re-lubricated, but it should also be subjected to investigation and the cause determined, rectified and information recorded, as should all relevant details referred to in this section (see Section 12).

9

Thorough Examination, Inspection and Testing

The nature of the assurance regime for a wire rope may be decided by practicalities as in some cases it may be more cost-effective to discard periodically rather than conduct thorough examination/NDE/tensile testing. Where periodic replacement is not the most viable option, the following techniques should be applied.

Thorough examination is a detailed appraisal of a wire rope conducted carefully and critically and, where appropriate, may be supplemented by NDE. Where NDE is not appropriate, tensile testing can be performed. Thorough examination is a more rigorous process than inspection.

Inspection consists of visual checks carried out at intermediate times between thorough examinations. Thorough examinations are conducted by a competent person with sufficient independence, see the definition of ICP in Section 1; inspections are conducted by appointed members of the vessel's crew.

9.1 Overview

Inspections should be carried out at the beginning of each work period and at intermediate periods identified in the company's procedures.

9.2 Inspection, Thorough Examination and Testing of Wire Ropes

9.2.1 Pre-Use Inspection

Good practice requires that all visible parts of a wire rope should be subject to a daily or weekly inspection as far as is possible (depending on how often the wire rope is used). Such inspection should be aimed at detecting general deterioration and deformation. If damage is detected, it should be reported and recorded and the wire rope examined by the appropriate competent person.

9.2.2 Thorough Examination

Thorough examination of at least the full working length plus three wraps of the wire rope (including hook end termination) should be carried out at periods not exceeding twelve months, be recorded and take account of:

- statutory requirements;
- type of appliance and/or design of the system;
- operational environmental conditions;
- method and frequency of operation;

- manufacturer's recommendations;
- results of previous inspections and thorough examinations;
- experience with previous wire ropes on the appliance or system;
- analysis of usage history;
- previous wire rope history – this should include review of weighload records/data loggers where available.

9.2.3 Deteriorated and Damaged Wire Ropes

Inspection frequency should be increased after the first broken wires or other deterioration is identified and recorded, or when subjected to overload or other harm suspected. Company policy should set out the procedures by which an appropriately competent person (IMCA M 187 – *Guidelines for lifting operations* – Section 6) inspects a damaged wire rope if there is any doubt about its safe operation.

An inspection should be carried out immediately after any incident which may have caused significant damage to a wire rope. The results of the inspection may identify the need for a thorough examination by a competent person.

9.2.4 Considerations for Programming Thorough Examinations

Consideration should be given to the provision of access to inspect/thoroughly examine wire ropes in situ. This should be agreed between the user and the competent person performing the thorough examination to ensure the objectives of the thorough examination can be met.

Equipment required might, for example, include use of a diesel powered, deck mounted spooler or another vessel such as a barge with suitable equipment on board. The vessel may have a complex system for wire ropes to be reeved through, which may mean that proper inspection requires access to difficult or restrictive areas.

Suitable risk assessments should be carried out.

In practice a high degree of planning will be required to inspect and maintain the wire rope at the work site in terms of time and equipment required.

When a lifting system has not been used for some time, companies should define a period after which inspection should take place before return to service. ISO 4309:2004 (Section 3.4.1.3) prescribes three months or more, however, in marine operations consideration should be given to environmental and other relevant aspects.

Effective wire rope integrity management requires accurate and comprehensive records to be kept of the methods, extent and findings of wire rope inspection and thorough examination (see Section 12).

9.2.5 Operating Cycles of a Wire Rope

Certain systems may provide data logging of the loading and number of cycles performed by a wire rope, however, they may not record sufficient information to identify the sections of the wire rope that have seen the most arduous service. Such information can be useful in understanding the rate of deterioration of a wire rope in a particular system.

Active heave compensation causes a small part of the wire rope to suffer repeated cyclic bending and loading and consequently deteriorate much more rapidly than other parts of the wire rope. Data logging systems can be useful in understanding the cumulative effect of such loading on the wire rope provided that they can be used to identify the sections of wire rope exposed to the most arduous duty.

To understand the consequences of such duties it is important to be able to identify the sections of wire rope that have been subject to the cyclic bending. For example, a crane using an active heave compensation system will have several sections of wire rope in different locations where the wire rope is subject to significant deterioration. Excessive deterioration can occur very rapidly where the same section of wire rope is subject to the most arduous duty for an extended period. Changing the position of the affected section of wire rope may extend the working life.

When heave compensation is active, the operating depth should be recorded. Data loggers may not record this vital information.

Procedures should be developed for the management of systems that suffer cyclic fatigue loading which enable the most arduous duty points to be identified. If they can be moved along the wire rope a much extended service life may be achieved.

Cyclic bending raises the temperature of the wire rope which can increase the rate of broken wires. In hot ambient conditions the temperature of the wire rope will already be raised before cyclic bending is initiated.

9.2.6 Cut Back and Tensile Test – General

In the case of heavy subsea utilisation, wire ropes may be cut back to eliminate the section most subjected to fatigue. Cutting techniques need to be safe and appropriate for the particular wire rope and relevant procedures should be available.

The cut back sample can then be subjected to tensile testing and post-retirement dismantling and internal examination in accordance with Section 11. If the result of the test confirms a continued acceptable breaking load, the wire rope could be re-terminated in accordance with applicable standards.

All relevant information should be recorded (see Section 12).

The procedures used in tensile testing should be consistent and rigorously checked to minimise variations in results. This should include the following stages:

- assessment of the wire rope test house to ensure that it has a suitable test bed with in-date calibration and suitably experienced engineers;
- proper preparation and cutting of the sample at the work site (see Section 9.3);
- appropriate packaging and transportation;
- proper preparation at the test house for the tensile test;
- careful assessment of the break location in relation to the termination;
- careful assessment of the condition of the wire rope sample as exposed as a result of the break test.

Companies' discard criteria for wire ropes used in different applications and the requirements of local regulations should establish when a wire rope would be discarded after a prescribed time together with a company approved load cycle management system.

9.3 Cutting Wire Ropes

When cutting wire ropes, precautions that need to be taken include but are not limited to:

- safety;
- referring to procedures and wire rope manufacturer's instructions, particularly with regard to serving;
- prior to cutting, secure servings should be applied each side of the cut location;
- the number of servings depends on the type of wire rope. If the wire rope is, for example, rotation resistant or low rotation type, or non-preformed, multi–layer or parallel closed type, at least two servings either side of the cut will be necessary;
- position and/or secure the wire rope to cater for sudden movement by the two parts of the wire rope when cut, allowing for a suitable straight length of wire rope each side of the cut;
- high speed abrasive disc cutters are often used (see IMCA safety card 11 – *Stay safe at the wheel – cutting and grinding safety*). Flame cutting is not recommended unless the wire rope is being discarded. Use appropriate PPE. Be aware of danger from sparks, disc break-up and fumes;
- if cutting lubricated wire rope, heat from the cutting method may create toxic fumes from the lubricant and/or toxic fumes or dust from material in the wire rope itself. Heated lubricant can also emanate from a wire rope and cause burns;
- ensure adequate ventilation, avoid build-up of fumes, avoid working in confined spaces.

9.4 Socketing

Socketing should be in accordance with resin system manufacturers' instructions, EN 13411-4:2004 or ISO 17558:2006.

Personnel should be trained and assessed in compliance with the company's competence assurance system to demonstrate that they are competent to carry out socketing in accordance with manufacturer's instructions.

Following any re-termination the socket should be inspected for good workmanship and general integrity. Particular attention should be paid to alignment, concentricity and lubrication at the socket entry. It is considered good practice to remove the serving at the socket entry after completion of the termination, to facilitate inspection and complete re-lubrication.

Details of re-socketing should be recorded (see Section 12).

9.5 Non-Destructive Examination

9.5.1 Overview of Instruments for Wire Rope Non-Destructive Examination

NDE instruments for steel wire ropes employ strong permanent magnets in the magnetic head. These magnets supply a constant magnetic flux that saturates the rope as it passes through the head. Total axial magnetic flux is measured by sensors with output being proportional to the amount of steel rope in the head and therefore indicating any change in cross-sectional area. This is commonly referred to as loss of metallic area (LMA) and can be used to indicate corrosion and or wear.

The main sensor types are coils surrounding the rope or solid state devices such as Hall effect sensors. Hall effect sensors are supplied with a constant current. Changes in magnetic flux density caused by changes in rope metallic area produce a proportional change in output voltage. Unlike coils, they are not sensitive to the speed of the rope passing through the magnetic head.

Magnetic flux leakage created by any discontinuity in the rope, such as a broken wire, corrosion pitting or inter-wire fretting, can be measured using differential sensors. These are commonly referred to as local faults (LF).

NDE instruments may be designed to detect LMA, LF or both.

9.5.2 Use of Wire Rope NDE Equipment

As it is not always practical or possible to open up a wire rope, thorough examination can sometimes be complemented by using electro-magnetic or other non-destructive examination (NDE), to detect broken wires and loss of cross-sectional area. Equipment is available which can scan wire ropes at the same speed as a pressure lubricator operates, thus it might, in some situations, be convenient to carry out both tasks during one spooling operation.

An initial NDE signature record should be made as soon as practical in the life-cycle of the wire rope.

The NDE device used should be:

- a dual function instrument, capable of simultaneously detecting loss of cross-sectional area and local discontinuities;
- used in accordance with the manufacturer's recommendations, with special regard to wire rope speed through the device, its resolution and the diameter and construction of the wire rope;
- used in conjunction with a system that can provide a permanent record of the output of the device. It is important that, on successive examinations, a comparison can be made to help detect any degradation. Further guidance is given in NDE specifications SANS 10369:2007 Edition 1.1 and ASTM E1571-06.

The same or a similar instrument should be used for successive examinations of a particular wire rope and careful records should be retained of any operating variables, instrument settings or calibration procedures, to ensure repeatability.

10

Causes of Wire Rope Deterioration and Guidance on Discard

10.1 Introduction

This guidance has been developed taking account of the discard criteria contained in ISO 4309:2004. Note: At time of publication of this guidance, ISO 4309:2004 is being amended and revised including changes to the criteria for the nature and number of visible broken wires.

Wire ropes are an essential element of almost all marine vessel operations. The wide range of usage demands an appropriate versatility from the designers and manufacturers of the large variety of wire rope required. This results in significant differences in the construction, diameter and length of the wire ropes, together with inconsistent deterioration from differing wear and damage rates.

Care should be taken by the personnel assessing the wire rope to simultaneously consider all factors when determining discard of the wire rope, that is, both wire rope diameter reduction resulting from core deterioration (10.11) of 3% of nominal diameter for rotation-resistant wire ropes, or by 10% for other wire ropes (ISO 4309:2004 Section 3.5.7) and reduction of 7% or more from external wear (see ISO 4309:2004 Section 3.5.8).

Examination of differing operational environments and types of wire rope use highlights the results of the various stresses and wear incurred. Life expectancy of a wire rope can vary significantly depending on its use.

The life expectancy of a wire rope might be based on the number of cycles that it performs, or a period of time, or because of some particular tangible factor detected during thorough examination/inspection, or at re-termination; for example the point at which a wire's protective galvanised coating starts to show signs of wear; or where other signs of deterioration are considered critical and may affect the relevant factor of safety.

Whenever damage or deterioration is detected on a wire rope the reasons should be ascertained and recorded in the wire rope's documentation. The information found may also be of interest to other wire rope users in the company's operations and the company wire rope integrity management system should encourage distribution of such information as necessary.

The international standard ISO 4309:2004 contains useful guidance on the causes of wire rope deterioration and clearly explains when discard is necessary.

The main types of deterioration of a wire rope in service are fatigue, corrosion, abrasion and mechanical damage. One or more of these effects may be present and all should be taken into consideration when selecting a wire rope for a particular service. Incorrect spooling of a wire rope on to a drum (see Section 7), badly aligned or inappropriate sheaves can cause serious damage.

When investigating the causes of deterioration consideration should be given to the entire wire rope system with regard to how it may be affecting the wire rope.

Information concerning specific causes of wire rope deterioration follows.

10.2 Fatigue

Example of fatigue failure

Fatigue in a wire rope is normally caused by repeated bending of wire ropes under tensile loading, for example, when wire ropes operate over sheaves and rollers, around drums and through heave compensation systems.

Generally, wire rope constructions with a greater number of smaller wires will have a greater resistance to bending fatigue.

Given correctly operating equipment in good condition, the main factors causing fatigue are, therefore:

- the number and degree of load during operating cycles;
- a small ratio of sheave to wire rope diameter (D/d);
- a small drum to wire rope diameter (recommended minimum is 18:1);
- incorrect fleet angles.

Fatigue breaks may not be visible in some forms of wire rope construction. In certain circumstances these breaks occur only in the internal wires and the wire rope may fail before there is any external indication of wire breaks.

Careful periodic thorough examination and inspection should be recorded and studied as part of the assessment process to determine the current and projected health status of the wire rope.

10.3 Broken Wires

Wire breaks in a wire rope are one of the most obvious indicators of degradation. However, these wire breaks may not be so evident on rotation-resistant wire ropes as the majority of wire breaks are likely to occur internally, thus highlighting the requirement for periodic internal examination and/or non-destructive examination. The rate of breakage increases with use and age.

ISO 4309:2004/Amd.1:2008 gives tables of number of visible wire breaks signalling discard. The discarded wire rope should be investigated to determine the cause(s) of the broken wires and the findings recorded.

If the grouping of broken wires occurs in a length that is less than six diameters of the wire rope (6d), or is concentrated in any one strand, it may be necessary to discard the wire rope even if the number of wire breaks is less than the maximum number shown in the tables of ISO 4309:2004/Amd.1:2008.

10.3.1 Localised Wear

Localised wear is symptomatic of a problem in the system in which the wire rope is installed and should be investigated by a competent person and the results recorded.

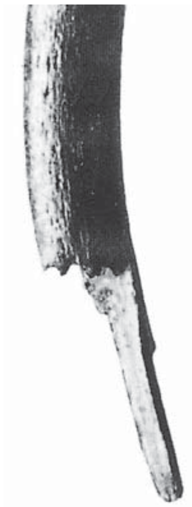
10.4 Broken Wires at Termination

Where broken wires are evident at the wire rope termination refer to the guidance in Section 3.5.3 of ISO 4309:2004.

10.5 Fracture of Strands

If a complete strand is fractured the wire rope must be discarded and the information recorded.

10.6 Corrosion



Example of corrosion failure

Corrosion is a main cause of wire rope deterioration and failure in service. Even in very dry conditions there is always some corrosion of unprotected steel wires. Corrosion will reduce the strength of a wire rope by reducing its metallic cross-sectional area. Fatigue will also be accelerated by corrosion creating surface irregularities which lead to stress cracking. Severe corrosion can result in a loss of elasticity of the wire rope.

In some respects, requirements for corrosion resistance and fatigue resistance are contradictory. For the former, a small number of large wires are an advantage, whereas for the latter a large number of small wires are to be preferred.

Subsea wire ropes are highly prone to corrosion. There is an increased risk of internal corrosion in wire ropes of dense construction, where lubrication may not be penetrating to the centre, especially when such wire ropes are used subsea.

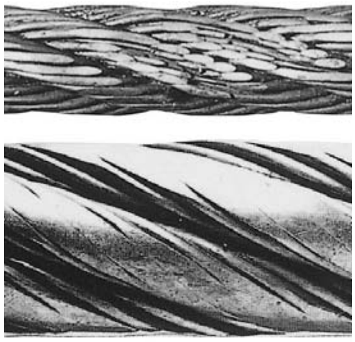
Corrosion of outer wires can be seen more readily, but internal inspection, including NDE, may be required to detect internal corrosion. ISO 4309:2004 (Section 3.5.10.2) states that wire slackness due to corrosion attack/steel loss is justification for immediate wire rope discard.

Internal and external corrosion often occur simultaneously. Internal corrosion should be suspected if there is:

- variation in wire rope diameter, which could be caused by rust build-up on internal wires increasing the wire rope diameter. A reduction in diameter can be caused by constant bending around a sheave. Therefore, diameter measurement and recording should form part of the thorough examination/inspection process to ensure accurate determination of diameter changes beyond the accepted criteria;
- loss of clearance between the strands in the outer layer of the wire rope, often linked with wire breaks between or within the strands.

If there is evidence of internal corrosion, the wire rope should be subject to thorough examination by a competent person. As some wire rope constructions cannot be opened up for internal inspection, alternative means (e.g. NDE) may be required. If significant internal corrosion is found then the wire rope should be immediately discarded and the information recorded.

10.7 Abrasion



Example of abrasion failure

Abrasion occurs primarily in the outer wires. Wire ropes pulled across abrasives will wear more quickly. Wire ropes with fewer but larger outer wires give a longer working life under abrasive conditions than those with many smaller outer wires.

Langs Lay has superior wear resistance and better performance in multi-layer spooling due to better contact against wires of the adjacent wrap.

The cross-sectional area of the wire rope will be reduced by abrasive wear and if the diameter decreases more than 7% of the nominal wire rope diameter, the wire rope should be discarded and the information recorded, even if no wire breaks are visible (see ISO 4309:2004 Section 3.5.8).

10.8 Crushing and Crossover Damage

The type of drum (e.g. plain or grooved), type of grooving (e.g. helical, parallel, or counterbalanced) and the condition of the grooves will influence the amount of damage to the rope when multi-layer spooling, particularly at the cross-over zones.

If correct back tension is not achieved when spooling a wire rope on to a drum severe crushing damage can be caused to underlying layers when the wire rope comes under sufficient load.

A wire rope that 'cuts in' to a lower layer on a drum due to poor spooling can become wedged and if the drum continues to rotate the shock loading can damage or even break the wire rope.

When paying out a wire rope that is trapped by a crossover it is possible that the direction of wire rope movement is reversed, that is, that the same direction of drum rotation actually starts to heave the rope in, creating a high potential for a lifting incident and probable significant damage to the wire rope.

The result of crushing or crossover can be severe including multiple broken wires, deformation and subsequent requirement to discard.

In systems that use multi-layer winding on to the winch drum, there is the possibility that local damage can be caused to the wire rope in the regions where the wire rope crosses from one layer to the next, or where the wire rope crosses over the turns in the layer beneath.

This can be mitigated by slipping and cutting a length sufficient to move all the layer crossover regions on the wire rope, and the groove crossovers, where this type of winding is used. This cut-and-slip does not eliminate the crossover damage but distributes it along the length of the wire rope. Such damage and cut and slip operations should be recorded.

10.9 Basket/Lantern/Birdcage Deformation

This form of deformation can occur as a result of a difference in length between the wire rope core and the outer layer of strands, for example, when wire ropes with high rotation characteristics are used between blocks that are free to rotate. Care needs to be taken in block and swivel connections as incorrect application can lead to premature deterioration.

10.10 Un-Laying

Un-laying can occur if wire ropes of different types and lay are joined in series. Un-laying could lead to catastrophic failure. If joining two ropes of different types is unavoidable, specialist advice should be sought and information recorded.

When lack of a swivel has caused a wire rope to un-lay under load, the outer wires may not show the damage done to the interior of the wire rope when off load.

10.11 Diameter Reduction as a Result of Core Deterioration

The core of a wire rope can deteriorate for a number of reasons. Even if the core cannot be accessed for internal examination, evidence of this can be indicated by a reduction in wire rope diameter. This can result in a significant loss of strength.

Any indicators of such deterioration should be supplemented by internal visual examination where practicable. In circumstances where this cannot be done, the wire rope should be thoroughly examined by a competent person (see Section 9) and the results recorded.

ISO 4309:2004 (Section 3.5.7) states that if these factors cause the actual wire rope diameter to decrease by 3% of the nominal wire rope diameter for rotation-resistant wire ropes, or by 10% for other wire ropes, the wire rope shall be discarded even if no broken wires are visible. Note: New wire ropes will normally have an actual diameter greater than the nominal diameter.

10.12 Local Increase in Wire Rope Diameter

An increase in the diameter of a low rotational wire rope is normally as a result of internal corrosion (this is caused by a build-up of rust). Where this is suspected, the wire rope should be thoroughly examined by a competent person.

Increase in wire rope diameter can also be the result of deformation of the core. The remainder of the wire rope would then become misshapen. If this condition results in the wire rope diameter increasing by 5% or more, then the wire rope should be immediately discarded (ISO 4309:2004 Section 3.5.11.6 refers).

10.13 Waviness

Waviness is the deformation that results in a wave pattern forming in the wire rope when in either a loaded or unloaded condition and should be recorded when detected.

While not necessarily resulting in any loss of strength, such a deformation will result in an imbalance in turn leading to wear and wire breaks.

Reference should be made to ISO 4309:2004 Section 3.5.11.2.

Mechanical damage due to rope movement over sharp edge projection whilst under load

Narrow path of wear, resulting in fatigue fractures, caused by working in a grossly oversized groove or over-small support rollers

Severe wear, associated with high tread pressure

Severe corrosion

Internal corrosion whilst external surface shows little evidence of deterioration

Typical wire fractures as a result of bend fatigue

Wire fractures at the strand, or core interface, as distinct from 'crown' features

Break-up of IWRC, resulting from high stress application

Looped wires as a result of torsional imbalance and/or shock loading

Typical example of localised wear and deformation

Protrusion of rope centre resulting from build-up of turn ('core popping')

Substantial wear and severe internal corrosion

Images in this chapter courtesy of Bridon International

10.14 Other Deformations and Damage

The types of deformation and damage noted below are fully described in ISO 4309:2004:

- core or strand protrusion/distortion;
- kinks/tightened loops;
- flattened portions.

Other types of damage and deformation which are seen only infrequently should be referred to the company competent person responsible for thorough examination for advice. These include, but are not limited to:

- weld spatter, exposure to strong heat, funnel exhaust, chemical spill or chemical fumes;
- wire ropes that have been subjected to exceptional thermal effects, externally recognised by the colours produced in the wire rope.

All damage detected should be recorded.

10.15 Combined Effect

An examiner should be aware of, and note, the cumulative effect of any combination of these factors in assessing a wire rope for continued service or discard. Care should also be taken to seek out and record the cause of deterioration wherever possible, especially if the mechanical components of the lifting system or faults in that system have been the cause of the deterioration.

In circumstances where there is a combined effect of two or more of the above factors at a location in the wire rope the personnel responsible for inspection should refer to the company's appointed competent person.

Given that there can be difficulties in arranging tensile testing at some geographical locations and with the logistics of doing so with some of the large diameter and length of wire ropes currently in use, it is vital that the greatest care be given to visual inspection and all other issues dealt with in this guidance. Proper management as described throughout this document will have a very high significance in ensuring wire rope integrity.

11

Post-Retirement Examination of Wire Rope Sections

When a wire rope is retired from service or when a part of a wire rope is made available from either a slip and cut procedure or destruction test, an assessment of the wire rope condition should be undertaken, principally to determine and record the mode and extent of any internal deterioration that would otherwise have remained undetected in service. The information gained will be extremely valuable to the competent person when carrying out subsequent wire rope examinations in service.

This procedure should involve disassembling (un-laying) the wire rope. This information should then be recorded and used to determine or validate the discard criteria.

Coinciding with a wire rope cut programme and re-termination, the ends of wire ropes that are being prepared for socketing should be examined closely for signs of any significant internal deterioration that would render the wire rope unfit for further safe use. Deterioration might be in the form of any corrosion (including that from fretting which will manifest itself in the form of rust or loss of zinc due to working in a marine environment), broken wires and internal wear of wires. An assessment of the state and effectiveness of internal lubrication should be made when the wire rope is being un-laid to form a brush.

The results of the examination should be recorded in relation to the specific wire rope in the company's wire rope integrity management documentation.

If there is any doubt about the condition and suitability of the wire rope for service further advice should be sought.

Both loss of elasticity and elongation are difficult to detect or measure when a wire rope is installed. Indicators such as measured reduction in diameter may be the only visible sign of deterioration from loss of elasticity/elongation. Once a wire rope has been retired from service, investigation of loss of elasticity and/or elongation may provide useful information with regard to wire ropes and discard criteria.

12

Wire Rope Records

12.1 General

The value of the company's wire rope integrity management system will be demonstrated by the quality of its wire rope records.

There are frequent reminders in this guidance to record the results of examinations and damage noted. Such records are vital to the reliability and credibility of a wire rope integrity management system.

It is important for each wire rope to have its own unique identification and a method of linking the wire rope to its documentation, for example, by an identifying sleeve or tag. The positive link between the wire rope and its records should provide both forward and reverse traceability. A data sheet complete with all periodic lubrication, NDE records, thorough examination and tensile test results recorded should also be accessible to relevant personnel as required. Manufacturer's original certification should be kept for the life of the wire rope.

Copies of in-date certificates should accompany the wire rope on its movements to and from work sites and be available when requested. Documents may be electronic or hard copy.

12.2 Individual Wire Rope Records

In the interests of good practice, and to help identify critical locations on a wire rope for inspection, it is recommended that full records should be kept for each wire rope, from its first installation to discard. This wire rope record forms an integral part of a wire rope integrity management system. It should record information including but not necessarily limited to the following:

12.2.1 Installation Details

At installation, details of the installed wire rope should include:

- date and name of manufacturer;
- relevant specification details (see Section 5);
- measured diameter, construction, wire grade and surface treatment as delivered;
- NDE trace where practicable;
- date and length installed.

12.2.2 Daily Inspections

Confirmation (and a record of comments when appropriate) of daily inspections should be kept.

12.2.3 Lubrication

A record of lubrication (date, lubricant used and application method) should be kept.

12.2.4 Operational History

Details of the wire rope's use in service.

12.2.5 Inspections, NDE and Testing

A record of inspections, NDE and testing, should include:

- earliest possible NDE trace;
- results of six-monthly and annual thorough examination;
- details of any length removed;
- details of number broken wires removed including location on rope and date of removal;
- details of how damage is marked on the rope (e.g. paint mark);
- details of how damage or deterioration was detected and whether it was acceptable;
- location in system of tested sample;
- results of internal examination;
- details of the NDE machine;
- details of pressure lubrication, if applicable;
- details of re-termination;
- data logger information from load monitoring systems;
- results of tensile tests;
- in storage inspection records.

13

Diving Bell Hoist Wire Ropes

13.1 Introduction

In addition to the above guidance there are further requirements for wire ropes used for diving. These special considerations are necessary because of particularly arduous duties including:

- man riding;
- passing through the splash zone;
- susceptibility to accelerated corrosion;
- internal wire breaks as a result of heave compensation;
- the maintenance of a factor of safety of 8:1 at all times.

13.2 Selection of Diving Bell Hoist Ropes

The influence of seawater on the degradation of wire rope shows that the performance of galvanised rope is considerably superior to that of rope manufactured from bright, ungalvanised wire. Not only does the zinc provide sacrificial protection to the steel from general corrosion, it also counteracts corrosion fatigue and corrosion fretting. It is therefore strongly recommended that only galvanised wire ropes be used for bell hoist ropes.

Rotation resistant ropes have a characteristic of developing large numbers of internal wire breaks long before external signs of deterioration become apparent, consequently particular care must be taken during inspection and thorough examination.

13.3 Maintenance

All sheaves and guide rollers in contact with the moving wire rope should be given regular visual checks for surface wear and lubricated to make sure that they run freely. This operation should be carried out at appropriate intervals (generally not exceeding more than one week during diving operations).

The wire rope should be maintained in a well lubricated condition using appropriate marine grade wire rope lubricants (as recommended by the wire rope manufacturer). The maintenance of internal lubricant is especially important for low rotation wire ropes, due to the way they are constructed.

In order to make sure that the inner layers of the wire rope remain well lubricated, an effective pressure lubricator should be used from the winch drum to the bell, commensurate with the depth to which the bell is to be deployed. This should be carried out at intervals not exceeding six months, and particularly at the end of an operating season, or if the diving system is not to be deployed for some time, as defined by the wire rope integrity management system.

Guidance on whether this form of maintenance is necessary and, if so, at what minimum frequency, can be given by the wire rope manufacturer in relation to a specific installation. Where damage is noted to reach a level which indicates that this form of maintenance should be carried out more frequently than every six months, then a more suitable wire rope should be installed, or there may be a discrepancy within the deployment arrangement and in this case it should be referred to the company appointed competent person.

When a new wire rope is installed, or when the end is pulled in, to avoid mis-spooling and subsequent damage, it is important that the wire rope is tensioned as it is wound on to the drum. The weight of the loaded bell in water will indicate the correct magnitude of the load to apply for this operation. The chosen procedure should avoid damage to the wire rope and in particular should avoid rubbing contact with a hard object.

13.4 Thorough Examination, Inspection and Testing of Diving Bell Hoist Wire Ropes

Diving bell hoist wire ropes should be thoroughly examined by a competent person at least every six months. It is recommended that once a year the six-monthly examination is supplemented by the use of an electromagnetic non-destructive examination (NDE) device appropriate for the wire rope concerned (see Section 9.5). The inspector should use the NDE device to supplement the visual inspection and in particular to help focus attention on areas of damage. Sections of the wire rope, from the winch drum to the bell, commensurate with the depth to which the bell is deployed, which should be given special attention, are:

- the part immediately adjacent to the socket;
- the part which is in contact with the sheave nearest the bell as the bell enters the water;
- in systems which operate with heave compensation, and where there has been repeated operation at the same depth, the parts of wire rope which repeatedly move on and off sheaves or drum when the bell is at operating depth.

During diving operations, where practicable, all accessible wire rope and associated equipment should be checked visually once each day. Particular attention should be paid to the termination and the part of the wire rope entering the socket. On those systems where the termination is inaccessible, then the correct inspection arrangements to facilitate inspection should be agreed with the company appointed competent person.

A visual inspection of the working length of the wire rope commensurate with the depth to which the bell is to be deployed, from the bell to the winch drum, should be carried out at appropriate intervals during diving operations. At the same time, because low-rotation wire rope tends to suffer internal damage, local reductions in diameter or lay distortions should be treated with the utmost suspicion as they are likely to indicate serious internal degradation. Any defects should be reported to the diving supervisor who should record them and refer to the company appointed competent person.

The wire rope (and associated equipment) should have been examined, tested and certified by a competent person (i.e. someone who, in the case of the wire rope thorough examination, has had suitable training and experience) not more than six months prior to any use.

Diving bell hoist wire ropes are required to be subject to the following procedure:

There should be an annual removal of a length of wire rope from just beyond the first sheave from the bell termination with the bell below the surface, allowing for swell, to be discarded. A length sufficient to provide test samples for two tensile tests should be cut from the bell end adjacent to the termination. In systems where there is a single vertical fall directly from the winch to the bell it will be necessary to cut right back to the winch. A sample should be tested to destruction to verify that the required factor of safety is maintained. Should the test prove unsatisfactory due to problems with test procedures or where the wire rope fails within a length equal to six wire rope diameters (6d) from the base of the socket or cone, a second test may be carried out. This alternative test should not be used as a way of avoiding discard where a valid test is performed which indicates low strength. In certain circumstances the competent person may waive the recommendation to cut all the way back to the first sheave.

The ultimate strength test to be carried out on a sample from the part subject to the most severe dynamic loading will be used to verify that a factor of safety of 8:1 is still being maintained and if not the wire rope should be discarded. Even if the factor of safety is being maintained but the result falls 10% below the MBF of the wire rope it should be discarded.

One of the tensile test samples should be dismantled and the internals examined in accordance with Section 11.

For installed equipment not in use, when the period of non-use exceeds one month, the wire rope and termination should be subjected to external visual inspection to identify any corrosion or damage over the length from the winch drum to the bell. This should be commensurate with the depth to which the bell is to be deployed.

If the period of non-use exceeds twelve months the wire rope should also be cut-back, re-terminated and a test to destruction conducted. The sample should also be examined internally.

Results of the examination should be recorded in the wire rope integrity management system.

In addition to the above there are specific requirements for examination and testing of the handling systems documented in IMCA D 024 – *Diving equipment systems inspection guidance note*. Requirements for functional testing and static testing of diving bell wire ropes and their terminations are given in Tables 29.1 and 29.2 of IMCA D 018 – *Code of practice on the initial and periodic examination, testing and certification of diving plant and equipment.*

Automatic discard after a fixed time period may be a cost-effective option for these ropes.

14

IMCA Safety Promotional Material

14.1 Safety Pocket Cards

IMCA pocket cards are useful reminders of safe working practices. Cards produced at the time of publication are:

1 Manual handling safety guide;

2 Preventing slips and trips;

3 Toolbox talks;

4 Lifting operations safety guide;

5 Lifting equipment safety guide;

6 Working at height;

7 Drugs and alcohol misuse;

8 Watch your hands;

9 Confined spaces can be deadly;

10 Workplace safety assessment;

11 Stay safe at the wheel – cutting and grinding safety;

12 Avoiding dropped objects;

13 Personal security;

14 Keep your eyes on safety;

15 Hazardous substances safety guide;

16 Caught between and pinch points – what you should know.

14.2 Safety Posters

IMCA safety posters at time of publication are:

1 Manual handling: Watch your back;

2 Preventing slips trips and falls;

3 Working at height: Safe use of ladders;

4 Avoiding dropped objects;

5 Vessel security.

15

References

Relevant standards and guidance at time of publication:

1 API 9A/ISO 10425:2003 – *Steel wire ropes for the petroleum and natural gas industries – Minimum requirements and terms of acceptance*

2 API RP 9B:2005 – *American Petroleum Institute recommended practice for application, care and use of wire rope for oilfield services*

3 ASTM E 1571 – 06 – American Society for Testing of Materials – *Standard practice for electromagnetic examination of ferromagnetic steel wire ropes*

4 EN 12385-1:2002 – *Steel wire ropes – Safety Part 1: General requirements*

5 EN 12385-2:2002 – *Steel wire ropes – Safety Part 2: Definitions, designation and classification*

6 EN 12385-3:2004 – *Steel wire ropes – Safety Part 3: Information for use and maintenance*

7 EN 12385-4:2002 – *Steel wire ropes – Safety Part 4: Stranded ropes for general lifting applications*

8 EN 12385-10:2003 – *Steel wire ropes – Safety Part 10: Spiral ropes for general structural applications*

9 EN12927–8: 2004 – Part 8 – *Magnetic rope testing*

10 EN 13411-4:2002 – *Terminations for steel wire ropes – Safety Part 4: metal and resin socketing*

11 IMCA R 004 Rev. 2 – *Code of practice for the safe and efficient operation of remotely operated vehicles*

12 IMCA R 011 – *The initial and periodic examination, testing and certification of ROV handling systems*

13 IMCA M 171 – *Crane specification document*

14 IMCA M 179 – *Guidance on the use of cable laid slings and grommets*

15 IMCA M 187 – *Guidelines for lifting operations*

16 IMCA D 018 – *Code of practice on the initial and periodic examination, testing and certification of diving plant and equipment*

17 IMCA D 024 – *Diving equipment systems inspection guidance note (DESIGN) for saturation diving*

18 ISO 2408:2004 – *Steel wire ropes for general purposes – Minimum requirements*

19 ISO 2532:1974 – *Steel Wire Ropes – Vocabulary*

20 ISO 3108:1974 – *Steel wire ropes for general purposes – Determination of actual breaking load*

21 ISO 4309:2004, including Amd.1:2008 – *Wire rope for lifting appliances – Code of practice for examination and discard*

22 ISO 12076:2002 – *Steel wire ropes – Determination of the actual modulus of elasticity*

23 ISO 17893:2004 – *Steel wire ropes – Vocabulary, designation and classification*

24 ISO 21669:2005 – *Steel wire ropes – Determination of rotational properties*

25 ISO 17558:2006 – *Steel wire ropes – Socketing procedures – Molten metal and resin socketing*

26 SANS 10369:2007 Edition 1.1 – South African National Standards – *Non-destructive testing – magnetic testing. Code of practice for NDE: Magnetic testing of steel wire ropes*

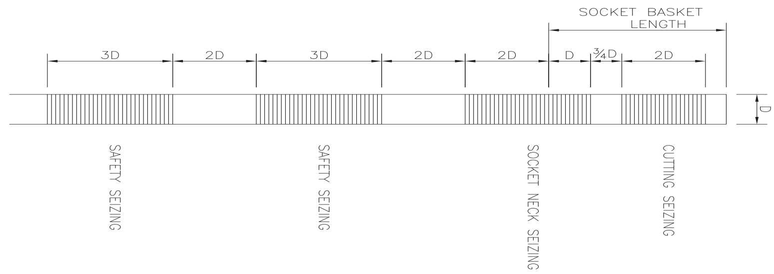
This list is not expected to be all-inclusive and there may be additional local legislation, guidance, standards and also client requirements to consider, depending on the flag state of the vessels involved, other jurisdictional issues and the location of the operation.

Appendix 1

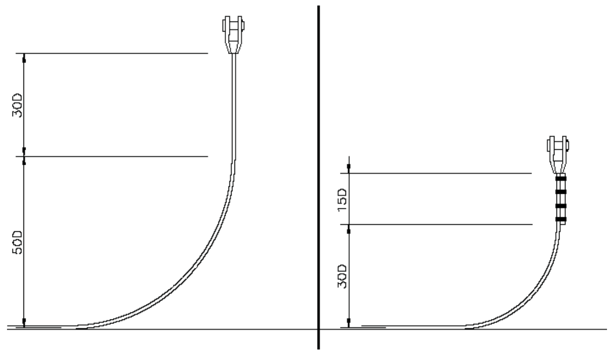
Example Certificate of Compliance: End Termination of Wire Rope

Illustrative example of an existing certificate for guidance only (companies' requirements will vary)

Wire rope certificate no	
Wire rope diameter (mm)	
Wire rope SWL (Te)	
Seizing wire diameter (mm)	
Length of seizing (mm)	
Socket basket length (mm)	
Is the socket new?	



Make of resin	
Case of hang off	
Temp. during curing	
Note: No load test is required	



Comments:

The seizing and the socket installation have been performed according to the company procedure			
Date		Signature	

Competent Person

Appendix 2

Example Wire Rope Purchase Specification

Illustrative example of an existing certificate for guidance only (companies' requirements will vary)

Delivery – *the following are required by the purchaser*

- Wire rope
- Transport reel
- Certificate
- 10 metallic ID tags

Intended use:

- ☐ Crane main lifting wire
- ☐ Crane auxiliary wire
- ☐ Crane luffing wire
- ☐ Other ____________________
- ☐ Tugger winch wire
- ☐ Guide wire

Technical requirements:

Rope category class (ISO 4309:2004 Annex E)		RCN =		
Rope construction				
Galvanised		Yes		
Rope core		☐ IWRC	☐ FC	☐ WSC
Direction of lay		☐ Left	☐ Right	
Type of lay		☐ zS ☐ sS ☐ S	☐ sZ ☐ zZ ☐ Z	
Nominal diameter (d)				mm
Rope length (L)				m
Minimum breaking force (MBF) (design)				kN
Production standard		☐ ISO 2408	☐ EN 12385	
Diameter tolerance		☐ 0%	☐ 5%	
Length tolerance	L <400m	☐ 0%	☐ 5%	
	L >400m	☐ 0m	☐ 20m	
	L >1000m	☐ 0%	☐ 2%	

Lebus drawings *should be attached by the purchaser to this specification*

Transport reel and terminations:

The rope shall be delivered on a transport with metallic tags for identification, with one tag each end. The outer end shall be seized and have a small pull eye welded to the wire end. The inner end shall be equiped with an open spelter socket. The following specifications should be met:

SWL	3% MBL
Socket type:	
Tension on transport reel	1% MBL
Total weight (wire rope and reel)	

Spooling on to final equipment

Spooling on to the final drum shall be the responsibility of:	☐ Supplier	☐ Purchaser
Spooling tension:		2% MBL

Certificate – *the following content must be included on the certificate to be provided by the supplier to the purchaser:*

- Certificate number
- Name and address of manufacturer
- Name and address of supplier
- Intended use of rope
- Nominal diameter
- Minimum breaking force (MBF)
- Length of delivered wire rope
- Ref. to production standard
- Rope type, RCN class, construction
- Actual breaking force (ABF) (less than 3 months before delivery)

Note: Manufacturer must verify that ABF is greater than required MBF.

Storage requirements – *the following information should be provided by the supplier to the purchaser:*

- Manufacturer's instructions for storage conditions
- Manufacturer's instruction for rotation of reel
- Manufacturer's instructions for examination and application of dressing