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North

Wire Ropes and Their Uses

Wire Ropes and Their Uses

CONTENTS

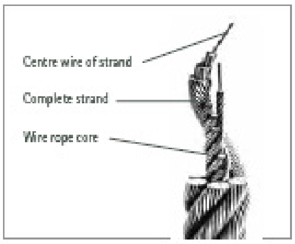
Introduction

Wires have for many years played an integral role in the daily operation and function of nearly every commercial vessel afloat. Applications will vary according to vessel type and purpose. The use, care and maintenance of wires should be included in every vessel's safety management system. However, accidents and incidents involving wires continue to occur and the question arises as to why.

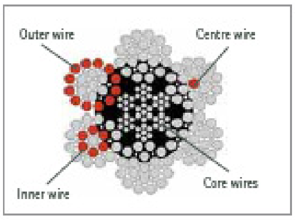
The scope of this briefing will cover some of the specific demands on wire ropes used on board and will address the inspection, maintenance, certification and handling requirements of each. Useful sources of reference, including international conventions and standards, are provided on the last page.

Wire Rope Construction

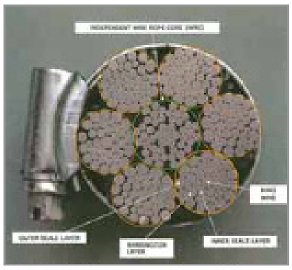
Before discussing the use and maintenance of ship's wires it is useful to understand how wire construction is tailored towards different applications. Wire rope is fabricated from strands of precise individual wires. The configuration of the wires and strands making up the wire rope is designed and manufactured to be able to work together and move with respect to one another to ensure the rope has the flexibility necessary for successful operation under tensile loading.



Wire construction *Source: Certex*



Cross section of 6x25 IWRC *Source: Certex*



6 x 36 WS-IWRC Warrington Seale Wire *Source: N Thompson*

The wire material is carefully processed and drawn from selected grades of steel to predetermined physical properties and sizes. A number of finished wires are then laid together helically in a uniform geometric pattern to form a strand. The required number of suitably fabricated strands is laid symmetrically with a definite length of lay around a core to form the finished wire rope.

In addition to properties such as material strength, minimum breaking load and corrosion protection, wire rope is identified by its construction - typically, the number of strands in the rope and the number of wires in each strand. For example, a wire rope of 6 x 36 construction denotes a 6-strand rope, with each strand having 36 wires.

The core running through the centre of the wire may be fibre, or of wire construction itself. For example, crane wires on ships are commonly configured with an independent wire rope core (IWRC) or wire strand core (WSC) as opposed to a fibre core (FC). Identification numbering, such as 14/7 & 7/7/1, refers to the respective arrangements of the strand and core wires' construction.

Wire Ropes and Their Uses (cont.)

The strand pattern comprises various combinations of wire diameters arranged to give different properties such as flexibility and fatigue, crush and abrasion resistance. Generally, a small number of large wires will be more abrasion resistant and less fatigue resistant than a large number of small wires. The strands are often made up from three standard wire arrangements known as Filler, Seale and Warrington.

Filler (F)

Characterised by the small spacer wires that lie in the gaps between strands of the inner layer to help position and support the outer layer. They provide crush resistance and flexibility.

Seale (S)

Characterised by having equally sized wires in the outer layer with the same number of uniform but smaller sized wires in the inner layer around a central core wire. The arrangement provides good abrasion resistance but less fatigue resistance.

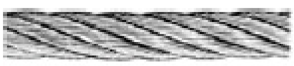
Warrington (W)

Characterised by having one of its wire layers made up of an arrangement of alternately large and small wires. This arrangement provides good flexibility and strength but lesser abrasion resistance.

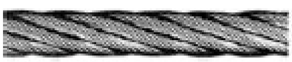
The notation WS, for example, is a blend of the Warrington and Seale patterns. In a typical wire rope construction such as 6 x 36 WS-IWRC, combinations of the three strand patterns are used because of the number of wires. Wire rope sizes could become too large if only one of the three standard patterns were used. The outer layers of the strands have equally sized wires whilst the layer underneath, has wires of alternately large and small diameter.

Wire rope lay

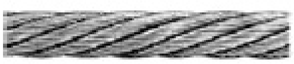
The helix or spiral of the wires and strands in a rope is known as the lay and there are three basic types:



Right hand regular lay



Right hand Lang's lay



Left hand regular lay

Left hand Lang's lay

Regular (ordinary) lay

This denotes rope in which the wires are twisted in one direction, and the strands in the opposite direction to form the rope. The individual wires appear to run roughly parallel to the centre line of the rope. Due to the difference in direction between the wires and strand, regular lay ropes are less likely to untwist or kink. Regular lay ropes are also less subject to failure from crushing and distortion because of the shorter length of exposed outer wires.

Lang's lay

This is the opposite to regular lay - the wires and strands spiral in the same direction and appear to run at a diagonal to the centre line of the rope. Due to the longer length of exposed outer wires, Lang's Lay ropes have greater flexibility and abrasion resistance than do regular lay ropes. Greater care, however, must be exercised in handling and spooling Lang's Lay ropes. These ropes are more likely to twist, kink and crush than regular lay ropes.

Right regular lay

This is the most common form of wire rope for cranes and usually furnished for all rope applications unless otherwise specified.

The lay-length is the linear distance a single strand extends in making one complete turn around the rope. Lay-length is measured in a straight line parallel to the centre line of the rope, not by following the path of the strand.

Strength

The responsibility for determining the minimum strength of a wire rope used in a given system rests with the manufacturer of the machine, appliance or lifting equipment. As part of this process, they should have taken into account any relevant regulations or codes of practice governing the design of the rope – often referred to as the coefficient of utilisation – and other factors that might influence the design. These include the design of the sheaves and drums, the shape of the groove profiles and corresponding radius, the drum pitch, and the angle of fleet – all of which have an effect on rope performance.

Once the strength (referred to as minimum breaking force or minimum breaking load) has been determined, it is then necessary to consider which type of rope will be most suitable. For instance, does it need to be rotation resistant, have a good fatigue performance, or be able to withstand particular types of abuse or arduous conditions?

Resistance to rotation

Some applications require use of a low rotation or rotation resistant rope. An example here would be lifeboat fall wires, and main and auxiliary hoist crane wires. Such ropes are often referred to as multi-strand ropes. Six or eight strand rope constructions are fine for low lifting heights or those with multiple falls but the most common choice to minimise load rotation on a single part system, block rotation, or 'cabling' on a multi-part reeving system, are low rotation ropes.

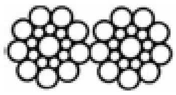
When loaded, steel wire ropes generate 'torque' if both ends of a rope are fixed, or 'turn' if one end is unrestrained. The torque or turn generated will increase as the load applied increases, and the degree to which this happens will be influenced by the construction of the rope. The tendency for any rope to turn will be greater as the height of lift increases. In a multi-part reeving system, the tendency for the rope to cable will increase as the

Wire Ropes and Their Uses (cont.)

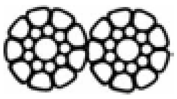
spacing between the parts of the rope decreases. Selection of the correct rope will help to prevent 'cabling' and rotation of the load.

Some wires have been designed to minimise problems associated with cabling and load rotation. As a general rule, however, if a rotation resistant rope is not needed, then it should not be used. A six or eight strand rope will always be more robust and better able to withstand excessive fleet angle and abuse than their more complex counterparts.

Fatigue resistance



Wire rope on adjacent drum laps can cause point contact and accelerated wear.



Compacted outer strands will reduce abrasion through improved contact conditions.

The rope's fatigue resistance is also an important factor. Steel wire ropes will suffer from fatigue when working around a sheave or drum. The rate of deterioration is influenced by the number of sheaves in the system, the diameter of the sheaves and drum, and the loading conditions. If fatigue resistance is an issue, then it is wise to select a rope containing small wires, such as 6 x 36 WS (14/7 & 7/7/1), as opposed to a rope containing larger wires such as a 6 x 19 S (9/9/1), which is more resistant to wear. Additional resistance to fatigue can be achieved by selecting a wire rope with a smoother surface than standard rope, which improves rope to sheave contact leading to reduced wear on both rope and sheave. An increased cross-sectional steel area and improved inter-wire contact also ensures that the rope will operate with lower internal stress levels. This ultimately results in greater bending fatigue life and long-term lower operating costs.

Resistance to abrasive wear

Abrasive wear can take place between wire rope and sheave, and between wire rope and drum, but the greatest cause of abrasion is often through 'interference' at the drum. If abrasion is determined to be a major factor in rope deterioration then a wire rope with relatively large outer wires should be selected

Crush resistance ropes

In multi-layer coiling applications, where there is more than one layer of rope on the drum, it is essential to install the rope with some back tension. This should be between 2% and 10% of the minimum breaking force of the wire rope. If this is not achieved, or in applications where high pressure on the underlying rope is inevitable – such as a boom hoist rope raising a boom from the horizontal position – then severe crushing damage can be caused to the underlying layers. Use of a steel core as opposed to a fibre core will help in this situation, and for this reason steel core ropes are always recommended for crane use. Additional resistance is offered by wires which have a high steel fill-factor and these ropes are also recommended for multi-layer coiling operations where crushing on lower layers is inevitable.

It should also be noted that a Lang's Lay rope resists interference at the drum better than a regular lay.

Corrosion resistance ropes

When the wire rope is to be used in a corrosive environment – which applies broadly across the marine environment – then a galvanized coating is recommended, and where moisture can penetrate the rope and attack the core, plastic impregnation should be considered. In order to minimise the effects of corrosion, it is important to select a wire rope with a suitable manufacturing lubricant, which should be re-applied regularly while the rope is in service.

Multi-strand rope that has parted due to internal corrosion *Source: Certex*

Routine Inspection

The time interval and extent of inspection and maintenance for wires will vary depending on their construction and use. These should be documented by the manufacturer and incorporated into the vessels planned maintenance system by a responsible officer.

As part of a continuous process of inspection for signs of general deterioration and damage, the general condition of all wire rope should be monitored on a daily basis when in use. All wires should be subject to inspection by a responsible person before work commences and on completion of a work-cycle. This is of particular importance if shock-loading is thought to have occurred during its operation.

When wire ropes are stored on drums, consideration should be given to accessibility in order to determine the timescale and logistics that will be involved in carrying out an examination of their entire length. Methods of examination should be included with maintenance logs to assist those involved with planning.

Although wires of six or eight strand construction hold up to 90% of their strength in their outer strands, it is the support provided by the core which maintains the wires efficiency and performance. Internal examination is therefore a vital component of any inspection regime and may be carried out by any competent person on board who has received the appropriate training.

The adjacent diagram shows a multi-strand rope that has parted due to internal corrosion. The exterior exhibited a minimum amount of corrosion, with no broken wires and limited wear. The rope parted because the core had corroded to such a degree that it collapsed causing the outer strands to

Wire Ropes and Their Uses (cont.)

impinge on each other leading to a catastrophic wire failure.

Periodic examination

By conducting frequent inspections and comparing the condition of the wire with the previous set of results a competent crew member can establish a rate of deterioration, this can then be used to programme planned maintenance and anticipate wire replacement. Any change to the working cycle of the rope, including lifting heavier individual loads, greatly accelerates the rate of fatigue damage to the wire. Inspection and maintenance programmes, including the frequency of inspection, must be modified to reflect this. Rate of occurrence of broken wires is one of the measures used to determine the condition of a wire. These are commonly referred to as the discard criteria.

Periodic examination should be carried out by a competent person and will involve the complete length of wire rope. The detail of the examination must conform to the statutory requirements of local legislation and the vessels Flag State. International standard ISO 4309 "Cranes - Wire ropes - Care, maintenance, installation, examination and discard" provides a framework for an examination and many of the considerations that are required when determining how often they should be carried out. Its scope includes deck, gantry, mobile, overhead and travelling cranes as well as derricks with both guyed and rigid bracing. The application of the wire and how often it is used, referred to as the number of work-cycles must also be taken into account. The adjacent diagram shows the areas where a rope is likely to deteriorate first and should therefore be included in the periodic examination.

Internal examination

Some specialized tools are required to carry out an internal examination, including:

- A 'T' needle (a flat spike with rounded edges) or a modified screwdriver for displacing outer strands to view the internal state of the core.
- Tape measure for measuring lay length.
- Chalk/electricians tape for marking any areas that require further examination.
- Cleaning materials (solvent) for removing debris or grease.
- Cheese wire (to remove debris/foreign matter from rope surface).
- Pliers for the removal of protruding parts of any broken wires.
- Clamps (wood or steel).

The examination should concentrate on evidence of broken wires, internal abrasion or friction, the degree of corrosion and internal lubrication.

To carry out an internal examination, attach the clamps approximately 100mm - 200mm apart and contra-rotate to un-lay strands. Care is required to ensure the strands are not moved to the point of causing permanent damage. The strands can be manipulated with the probe to facilitate the examination.

Once the examination is complete, a dressing can be applied and reverse torque used to re-bed strands onto the core. At a point of termination one clamp will usually be sufficient and the procedure is the same. Results must be recorded and compared to the discard criteria.

Internal examination Source: Certex

Plastic Sheathing – safety issue

Totally encasing steel wire in plastic sheathing when it is to be used in the marine environment has significant implications for maritime safety, especially when the wire must be regularly inspected and maintained in order to remain fit for purpose.

Encasing wire rope in plastic sheathing prevents the wire being lubricated, maintained and inspected, and can accelerate the onset of corrosion through the retention of salt water within the core of the wire rope, ultimately resulting in the weakening and failure of the wire.

Examining ropes running over sheaves

The length of rope running over sheaves are the most heavily worked parts of the rope and the examination should concentrate on these. The state of the drum anchorage, the area immediately adjacent to any termination and areas affected by heat damage should also be included.

The rope MUST NOT be under any tension during this process.

Discard Criteria

Stress, abrasion, bending, crushing and corrosion are the most common sources of damage to wires. However, rotation, vibration, cabling and elongation may also occur under certain circumstances. These can in extreme cases lead to catastrophic wire failure.

A detailed external examination should compare the wire against the discard criteria for each type of wire. These criteria are determined in consultation with the manufacturer and include:

Number of broken wires

The number of permissible broken wires will depend on the function of the wire and will include the rate of breakage occurrence and grouping of broken wires.

For example, a single layer 6 x 7 fibre core wire rope used for a cargo wire should be discarded if 2 or more wires are visibly broken in a length equivalent to 6 diameters.

Fractured strands

A strand that has completely fractured will require the wire to be discarded.

Wire Ropes and Their Uses (cont.)

Decrease in elasticity

This can be quite difficult to detect and it may be necessary to consult a wire specialist if it is suspected. However, warning signs can include a reduction in the diameter of the rope, elongation of the lay length, signs of compression between strands along with the appearance of fine brown powder, and an increase in the stiffness of the wire.

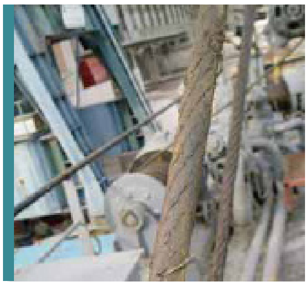
Although broken strands may be absent from a wire that has a reduction in elasticity this condition can lead to catastrophic wire failure and should result in the immediate removal of the wire from service.

External and internal corrosion

External corrosion is easier to detect than internal. Discolouration will be accompanied by an apparent slackness between wires, which is a result of a reduction in the cross-sectional area of the wire. Corrosion can rapidly accelerate fatigue damage by causing surface deformation which can lead to stress cracking.

Other discard criteria may include:

- Heat damage.
- Rate of permanent elongation.
- Reduction in tensile strength.
- Length of service.
- Number of life-cycles.
- Broken wires at termination points.
- Reduction in diameter.



In addition to these considerations a detailed examination of the wire will be required if there has been a prolonged period of inactivity or a change to the characteristics of the loading and discharge pattern of the vessel.

Evidence of broken wires should trigger a more aggressive inspection regime, grouping of broken strands may indicate inherent weakness in the work procedure for the particular wire affected and should be monitored closely if not removed from service. Once broken wires have been identified it is important that they be removed without further damage being done to the wire or injury to crew. Pliers may be used to work the broken wire back and forward until it breaks close to the strand. Non-destructive testing will greatly assist wire inspection in applications where there is an increased risk of internal wire damage. In circumstances where non-destructive testing is employed, initial reference data must be determined as soon as possible after the wires installation to allow subsequent comparisons to be made.

Maintenance and Records

The lifespan of any wire will depend to a great extent on the way that it is maintained on board. The technical nature of wire manufacture demands that planned maintenance programmes be developed in collaboration with the manufacturer before the wire is supplied to the vessel. Where lubrication or dressing of the wire is required this should be applied prior to the wires installation on board and reapplied at pre-determined intervals determined by the manufacturer. Lubricants may need to be worked into the core of the rope during application if they are to serve their intended purpose.

If cleaning of the wire is required before lubrication, care must be taken to ensure substances used are compatible with the components of the wire and lubricants to be used.

Changes to operating practices and environmental conditions will require planned maintenance programmes to be flexible and anticipatory to ensure the continued safe operation of wires on board.

Examination records

Detailed records of examinations must be maintained, this will allow those responsible to identify patterns of damage occurrence. This information can then be used in conjunction with the anticipated cycles of work to determine expected deterioration prior to the next scheduled inspection. On detecting damage which exceeds that predicted in the maintenance records, a re-evaluation of the life expectancy of the wire will be required and this should be followed by an inspection of all other associated machinery in order to establish the source of the accelerated damage. International standard ISO 4309 contains examples of rope examination records for both individual inspections and running records. Details should include:

- Number of visible broken wires.
- Measurement of reduction in diameter.
- Degree of abrasion.
- Degree of corrosion.
- Degree of damage and deformation.
- Location of Damage and an overall assessment of wire condition.

The degree of deterioration may be assessed on a percentage basis:

20% = slight

40% = medium

60% = high

80% = very high

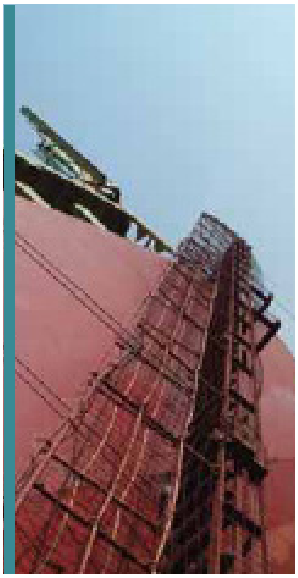
100% = discard.

Wire Ropes and Their Uses (cont.)

Storage

When not in use, wires should be stored in dry conditions or otherwise protected from chemicals and substances that may harm their protective dressing or lead to corrosion.

Accommodation Ladders



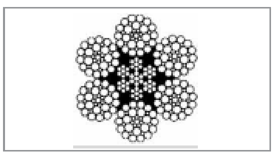
Accommodation ladders are the most commonly used means of access to ships. On vessels that have large freeboards, they may fulfil the role of general access when in port and facilitate pilot boarding and disembarking at the beginning and end of passage. They are generally located on the main deck, constructed in a composite fashion with collapsible hand rails and platform. This allows them to be stored with minimum intrusion into deck space when the vessel is on passage.

The complex nature of this semi-permanent design may cause problems. Removable stanchions and hinged components are often damaged by excessive wear during the rigging and dismantling process.

Article 15 of International Labour Organization (ILO) Convention 152 requires a vessel's access to be "adequate, safe, properly installed and secure".

SOLAS regulation II-1/3-9 requires means of embarkation/disembarkation on new ships built on or after 1 January 2010 to be constructed, tested, installed and maintained in accordance with IMO Circular MSC.1/Circ.1331.

Accommodation ladders and gangways fitted on ships constructed before 1 January 2010, which are replaced after that date must, in so far as is reasonable and practicable, also comply with MSC.1/Circ.1331.



Cross section of 6x 36 IWRC accommodation ladder wire *Source: Certex*

Although only applicable to new vessels and replacement installations, inspection and maintenance criteria contained in circular 1331 may benefit planned maintenance procedures for existing ships' means of access.

Construction of accommodation ladder wire

The stowage location of ladders on high freeboard vessels can require them to be lowered a significant distance to the vessel's shell door access. This can require large amounts of wire to be spooled on winch drums. Wire used for this purpose must be compact, have a small diameter and be flexible enough to rotate around the multiple sheave configurations associated with these ladders.

Strands constructed of 36 wires give good flexibility while maintaining shape and geometry with an independent wire rope core, reducing the effect of compression and crush damage.

Principle causes of damage

Corrosion

Storage on the main deck exposes the wire to high levels of salt water contamination. The small diameter of wire required limits the effectiveness of internal core lubrication and weakens the wires resistance to corrosive damage.

Abrasion

Damage often occurs as a result of pulley and sheave seizure, wires can be damaged and kinked during rigging and dismantling. Poor supervision of ladders landed on the quay may result in bights of wire being exposed to quay surface abrasion, contamination of lubricant and crush damage.

Cutting in

This occurs when rope buries itself under tension in a wire that has been spooled poorly underneath. If not monitored closely, this can lead to jamming causing counter rotation, crushing and kink damage.

Crushing

Uneven spooling can result in crossed wires on the drum - under load this can result in crush damage. This may also occur to exposed wire which have become snagged or nipped on the quayside.

Fatigue

The rate of fatigue damage is accelerated by frequent bending of the wire while under load - tight nips round small diameter pulleys and kinking damage during rigging are examples. The rate of fatigue is accelerated by poor lubrication and exposure to corrosion damage.

Care and handling

The complex nature of ladder construction requires that the rigging process be supervised by a responsible officer. During this process a careful inspection should be conducted to ensure each component of the ladder is free from damage, fit for purpose, secure and suitably lubricated. The supervising officer should inspect the wire for signs of damage and fatigue. Care should be taken to ensure a suitable amount of back tension is applied during spooling. This will reduce the likelihood of jamming when load is applied to the winch.

Most ladders are designed to rest on the quayside and pivot at the point of attachment to the ship's hull. This can result in a significant concentration of loading stress, often compounded

Wire Ropes and Their Uses (cont.)

by movement of the vessel on the berth. Supervision of the vessel's access can monitor the extent of this movement and prevent the ladder becoming overloaded when large groups are assembled waiting to board or disembark. This is particularly important when the vessel is at anchor and the ladder is entirely suspended from the wire and davit arrangement. There have been a number of fatal accidents under these circumstances with suspension wires parting, dropping ladders into the water. Signs indicating maximum loading should be attached to the ladder both at the top and bottom to advise on the capacity of the ladder at any one time.

Maintenance and inspection

An inspection by a responsible person should take place prior to the preparation of the ladder for use and subsequent to dismantling. This should include wires, all moving parts and points of attachment. All wires used to support the means of embarkation and disembarkation must be maintained as specified in SOLAS regulation III/20.4 for lifesaving launching appliances. This will require monthly inspections recorded in the log book (with special regard for areas passing through sheaves) and renewal when necessary due to deterioration of the falls or at intervals of not more than five years, whichever is earlier.

Classification Societies will initiate inspections as part of Cargo Ship Safety Equipment and Passenger Ship Safety Surveys as and when authorised by the ship's flag state administration.

When accommodation ladders are used for pilot transfer due regard shall be paid to SOLAS V/23 – Pilot transfer Arrangements

Storage on the main deck exposes the ladder, wire and winching mechanism to the extremes of environmental damage. If possible, wire should be removed from winch drums before the vessel embarks on a long ocean voyage. If this is impractical, maintenance procedures should incorporate particularly aggressive lubrication regimes to compensate and suitable protective coverings should be used when the ladder is not in use.

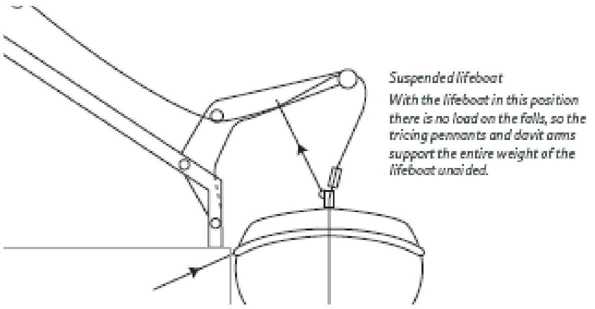
Discard criteria should take account of the high levels of corrosion associated with this application.

Lifeboat Wires

Lifeboat systems have been subject to a great deal of scrutiny and investigation recently following accidents during statutory drills and maintenance procedures.

Several independent investigations have been carried out by Flag State administrations and other organisations, such as the UK Maritime and Coastguard Agency (MCA) and Marine Accident Investigation Branch (MAIB). Their conclusions concur that although causation may not be directly linked to fall wire fatigue, its integral role in the overall function of the system demands that those involved with the maintenance, inspection and operation of lifeboat systems fully understand the complexity of the design and the contribution of each component.

Tricing pennants, gripe wires and hanging-off pendants are subject to similar sources of fatigue and misuse as fall wires and must not be overlooked during inspection and maintenance programmes. Tricing pennants in particular have been identified by several research projects as being subjected to increasing levels of misuse by poorly supervised crew members who overload them during drills by lowering boats to a point where the weight of the boat is mostly transferred from the fall wire to the tricing pennant. This dangerous practice can lead to slack fall wires, tricing pennant failure and the potential for the consequential failure of the entire davit structure. These risks highlight the importance of a responsible officer supervising all activities that involve movement of the boat and maintenance activity conducted by ship's crew. Robust risk assessment procedures must precede all examination and maintenance work.



Construction

Fall wires are required to be both flexible and stable in order to withstand the shock-loading and rotation that can be present during lowering and recovery, this requires a larger number of small diameter wires within the structure of the rope. Fall wires may be certificated to remain in service for up to five years. Lubrication and the corrosion resistant quality of its construction are therefore very important.

Principle causes of damage

Corrosion

Persistent exposure to environmental extremes attacks the construction of fall wires. This is compounded by restricted access to long lengths of wire spooled on winch drums prohibiting penetrating dressing and lubrication.

Abrasion

Seized davit sheaves and poor rope leads will accelerate the extent of damage to the larger number of exposed wires associated with this type of rope.

Crushing

High freeboard vessels with a large amount of fall wire can suffer from "cutting in" during bad spooling with low back tension resistance increasing the likelihood of crush damage.

Wire Ropes and Their Uses (cont.)

Jamming

Uneven movement of davits and fall wires can lead to slack wire and bights forming between sheaves, unchecked this can result in misalignment and slippage of the fall wire off the sheave blocks jamming fall wires between sheave and davit structure.

Care and handling

The accident investigations referred to earlier established that many of the incidents associated with lifeboats involved falls, sheaves, blocks, tricing pennants, and gripe arrangements.

Davit alignment relies on the precise tensioning of fall wires. During lowering and recovery operations due diligence must be exercised to ensure even spooling on winch drums. Smooth operation of the winch control is necessary to avoid sharp juddering movement of the davits and boat. Sheaves are often set at angles other than vertical. Slippage of wire off sheave blocks may result in the wire jamming between the sheave and cheek plate.

Crew members should be made aware of the dangers associated with lowering the boat to embarkation level beyond the point of weight transfer from fall wire to tricing pennant. Larger capacity lifeboats that are bowsed-in alongside the vessel close to the davit head produce fall wire angles that are increasingly removed from the vertical. This produces increasingly large horizontal moments and transfers unacceptable loads on to both the davit arm and tricing pennant.

Maintenance and inspection

All lifeboat wires are required to be inspected weekly to ensure immediate readiness and monthly to ensure they are maintained in good order. Current regulations require wires to be turned end-for-end at intervals not exceeding 30 months and replaced at intervals not exceeding 5 years, subject to the condition of the wire. An alternative arrangement removes the need for 'end-for-ending' if wires are inspected frequently and renewed at intervals not exceeding four years, subject to wire condition.

More detailed maintenance and servicing guidelines than previously available have been promulgated by the International Maritime Organization (IMO) in the annex to IMO circular MSC/Circ.1206/Rev.1. This includes:

- Release gear, including testing procedures for on load mechanism.
- Davit limit switches, sheaves and lubrication of moving parts.
- Winch power supply, controls and braking arrangement.

On vessels that are exempt from the launching requirements specified in International Convention for the Safety of Life at Sea (SOLAS) chapter III, regulation 19, planned maintenance schedules should take account of periods of inactivity. Discussion with manufacturers should determine suitable dressings and lubricants to reflect these time intervals.

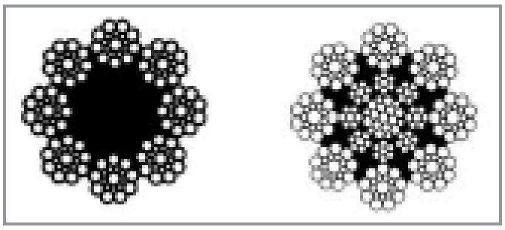
Additional information on Lifeboat Release and Retrieval Systems can be found in IMO MSC circular MSC.1/Circ.1392.

Reports and records

Detailed records of inspection and maintenance work must be maintained and signed by the maintenance company's representative, ship's master and those involved in conducting the maintenance programme. When repairs and servicing have been completed a statement confirming that lifeboat arrangements remain fit for purpose should be issued by the manufacturer's representative or individual certificated by them.

Elevator Wires

Elevators, or lifts, have been used on merchant vessels for many years. The wires used to operate them are referred to as 'hoist ropes' and commonly have either a fibre or steel core and are of 6 or 8 strand construction. Wires are normally 'pre-formed', which ensures that an individual wire that parts will not adversely change the geometry of the rope.



Cross section of 8x19 dual tensile fibre or steel core wire elevator wire *Source: Certex*

Both regular lay and Lang lay are used in hoist rope construction. Each has quite different advantages. Regular lay is easier to handle and will be more resilient to crushing damage. Lang's lay, with external wires being exposed to a longer lay length reduces wear more effectively than ordinary lay thus improving the wires fatigue life. Whichever construction method is selected, it is important that it be maintained throughout the operation of the lift.

The fibre core, which may be natural sisal or synthetic polypropylene, is impregnated with lubricant during manufacture to ensure a gradual release during the operation of the wire. This facilitates mechanical movement between individual wires during bending and also offers some protection against corrosion. Rate of lubricant release is critical, too quick and the wire will slip on the sheaves, too dry and abrasion damage will result.

Combination wire construction utilises high tensile wire in the inner strands where their harder more brittle construction can

Wire Ropes and Their Uses (cont.)

be protected by softer more malleable low tensile strands on the exterior. Whichever wire is selected its construction must be compatible with the material used to manufacture the sheave configuration.

Sets of lifting ropes must share identical properties throughout their length, particularly their stretch characteristics under load. Manufacturers must therefore ensure that pairs of rope are taken from the same production length.

Principle causes of damage

Fatigue

Flexibility is a vital component in a hoist rope, continual bending and compression over sheave blocks will permeate throughout the lifespan of the rope, which, depending on working conditions is normally between 3 and 8 years. 'Metal fatigue' will produce spontaneous cracks that spread along the length of the wire until fracture.

Abrasion

Insufficient lubricant will result in excessive internal wear known as fretting corrosion. Individual wires rub together producing an appearance similar to rust damage. This can lead to premature failure of the rope.

Stretch

Slight discrepancies in diameter and elastic properties of a particular wire can result in one of a pair of hoist ropes stretching slightly more than the other, or travelling more quickly through the rope cycle. Without a compensation mechanism in the lift operation this can lead to slippage on the sheave during use and affect the traction properties of the sheave and wire combination. Elastic stretch could commonly amount to about 6mm for every 10 metres of travel, permanent stretch can account for as much as 40mm per 10 metres of length when a wire is new, this is a symptom of 'bedding in' and will occur very quickly. A further stretch by as much as 60mm per 10 metre length is not uncommon over a number of years.

Maintenance and inspection

Inspection intervals for hoist wires will be dependent on local administration and Flag State regulation. Subject to the number of rope cycles, industry best practice recommends a careful examination at six monthly intervals. The extensive bending which hoist ropes experience demands careful assessment of fatigue cracks on individual wire strands. Inspections should also include termination points and the means of attachment to the car and counterweight. Sheaves are designed to be softer than the wire and will shed slivers as a result of rope slippage. If present, the cause must be investigated thoroughly.

High operating temperatures, traction, fast line speeds and small bending ratios all reduce the efficiency of lubrication. Additional lubrication during the operational life of the wire will clean and maintain traction, penetrate into the wire assisting to repel moisture and reduce abrasion damage. Small amounts applied frequently will produce the best results. Lubricating compounds must be approved by the manufacturers. Sheave grooves should exhibit a slight sponge like texture to the touch when the wire is well lubricated. If the finger remains dry, the rope requires lubrication. Governor ropes should not be lubricated after installation.

In addition to discard criteria applicable to all wire ropes, the following require particular attention;

- Surface wear damage to exterior wires caused by sheave traction and slippage;
- Inequality in tension between paired ropes;
- Excessive stretching, this can be monitored by the counterweight bottom over-run dimensions;
- Inequality in wire diameter throughout the length of the rope;
- External evidence of internal fretting corrosion;

In the absence of any national regulations or instructions from the equipment manufacturer the adjacent table provides a general guide to broken wire discard criteria.

The competent person inspecting the wire must be aware of the possible increase in internal damage if operating sheaves are constructed from material other than cast iron or steel.

Care and handling

There is little handling of hoist ropes once installed, however they are vulnerable to damage from sharp edges and corners during transportation and shipping. Ropes must be protected from wet damage, humidity and heat. Lubricants can soften in strong sunlight and drip from the wires. The method of unreeling must ensure there is no kink damage and no contamination of the wire, pulling the rope over sharp edges during installation can produce torque which can de-stabilise its structure. Some manufacturers mark the rope to monitor the amount of twisting during installation, excessive twisting can rapidly reduce the life expectancy of hoist wire and may require correction.

Number of Visible Broken Wires Single Layer Ropes with Fibre Core Operating in Cast Iron or Steel Sheaves				
Condition	Replace ropes or examine within a specified period as stated by the competent person		Discard ropes immediately	
	Class 6 x 19 FC	Class 8 x19 FC	Class 6x19 FC	Class 8x19 FC
Broken wires randomly distributed among the outer strands	More than 12 per rope lay*	More than 15 per rope lay*	More than 24 per rope lay*	More than 30 per rope lay*
Broken wires predominating in one or two outer strands	More than 6 per rope lay*	More than 8 per rope lay*	More than 8 per rope lay*	More than 10 per rope lay*
Adjacent broken wires in one outer strand	4	4	More than 4	More than 4
Valley breaks	1 per rope lay*	1 per rope lay*	More than 1 per rope lay*	More than 1 per rope lay*
*The length of one rope lay is approximately equivalent to 6 x *d* (where *d* is the nominal rope diameter)				

Table of Discard criteria for Suspension ropes, Governor ropes and compensating ropes

Wire Ropes and Their Uses (cont.)

Mooring Wires

Wire failure continues to feature as a causative factor in accident investigations into incidents that occur during mooring operations. These are almost always serious and sometimes fatal. Each mooring operation requires careful planning to ensure that a safe working environment for the crew can be maintained while reducing the most likely sources of fatigue and stress damage to the wire.

Environmental exposure, abrasion damage and shock-loading all play a part in accelerating wire fatigue. Significant loads can be experienced unexpectedly during any berthing manoeuvre. Incidents of this type will frequently expose weakness within the structure of the rope and accelerate fatigue to the point of wire failure. Designing a mooring wire with sufficiently robust qualities to withstand these external forces can be particularly challenging - often a technical solution to one source of fatigue may not be compatible with the requirements demanded by the application. Maintenance regimes must therefore be designed to maintain the flexibility and subsequent life span of the wire, while inspection programmes should enable a ship's crew to identify symptoms of fatigue early in order to protect the crew from the consequences of wire failure.

Construction

Ropes that are constructed with wires of a larger diameter will be less vulnerable to corrosion damage, This characteristic is also desirable for abrasion resistance properties. However too large a diameter of wire will produce a less flexible rope and reduce resistance to fatigue damage. Compromise is therefore required to produce a wire that can satisfy the demands of mooring operations and also be suitably lubricated to protect it from corrosion.

Wires that may be exposed to crushing damage benefit from a wire core and equal lay construction, this will produce a more robust shape that is less likely to deform under pressure. A typical mooring wire construction consists of six strands of 36 wires with an independent wire core (6x36 IWRC). Mooring wires can be supplied from as little as 10mm to over 100mm diameter.

Resistance to shock-loading can be difficult for a manufacturer to include in the design of a rope. Sometimes a length of nylon multiplait rope is fitted at the working end of the mooring wire to absorb most of this shock. Fitting a nylon tail, which has a lower breaking strain than the wire, also ensures that the cheaper and easier to replace tail, parts before the wire when accidental overloading takes place.

Principle causes of damage

Corrosion

This is the most common cause of wire rope failure. Mooring wires located on drums at the extremities of the vessel can be subject to extensive environmental exposure.

Cutting in

This occurs when wire rope buries itself under tension in a wire that has been spooled poorly underneath it causing counter rotation during berthing and kink damage. If undetected by crew members this will not only seriously damage the wire and winch, but could result in serious injury to the crew.

Crushing

This can seriously damage the structure of the rope by separating strands which will change the geometry of the rope reducing the breaking strain significantly.

Abrasion

Some sources of abrasion damage are unavoidable - stevedores repeatedly dragging the wire over quayside knuckles will produce progressive wear in every mooring wire. Preventable abrasion damage occurs when a wire is led through poorly maintained leads which have become seized or have uneven corroded surfaces.

Fatigue

The extent of a wires flexibility should be discussed with the manufacturer prior to purchase. Frequent excessive bending of the wire while under load will produce fatigue damage, which will be accelerated if the wire is being used beyond its design specification. Careful consideration should be given to the characteristics of the wire when old wire is being replaced by new. Before ordering new wire those responsible need to ensure that the diameter of roller leads pedestal rollers on board are compatible with the construction of the wire and the manufacturer's recommendations.

Care and handling

Handling of mooring wire ropes is a hazardous activity and all those involved should receive appropriate instruction on the dangers and precautions required to reduce the risk of injury.

Training should include the limitations of use and possible causes and consequences of poor handling and insufficient maintenance. Topics could include but not be limited to:

- Avoiding sharp angles in mooring arrangements.
- Correct use of leads and pedestal rollers.
- Avoiding snap-back zones.
- Danger of broken strands.
- Hazards of lubricants in contact with skin.
- Precautions required when working with single drum, split drum and drum ends.
- Wires stored on drums.

Mooring operations are no different to any other hazardous activity on board the vessel and require a risk assessment to be carried out as part of the briefing and preparation process. The mooring plan should be discussed with all those who will be involved to establish the most appropriate leads and rollers to be used for each wire.

Wire Ropes and Their Uses (cont.)

Maintenance and inspection

Because of the exposed location of mooring wires and their vulnerability to fatigue damage, strict maintenance and lubrication schedules must be maintained to prevent corrosion. Wires should be removed from winch drums for detailed examination at a time interval based on the manufacturer's recommendations and the wire's discard criteria. The wire should be cleaned with products compatible with the wire, intended lubricant and approved by the wires manufacturer.

During cleaning crew members must be aware of the possibility of broken wires and wear appropriate hand protection. Every broken wire detected should be brought to the attention of the supervising officer. Wire manufacturers will stipulate the permissible maximum number of broken strands in a given wire length. A general rule of thumb for mooring wires would be breakage in 10% of the visible strands in any length of wire equal to 8 diameters. If this number is exceeded then the wire should be condemned and removed from service.

Once cleaned and examined, damage to the wire must be recorded in planned maintenance records and compared to the manufacturers discard criteria and previous damage notes. This is also an ideal opportunity to inspect the end fitting of the wire to the drum and check method of attachment. When the responsible officer is satisfied with the wires condition it can be treated with the approved lubricant and greased if required. Care must be taken to ensure that the lubricant penetrates between the surface wires and into the central core of the rope. During re-spooling crew must ensure sufficient back tension is maintained, this will not only protect the wire from crushing damage but will help prevent cutting in and kink damage during future use.

Routine external examination should be incorporated into pre-arrival and departure checks in accordance with the vessels safety management system:

- All leads, rollers and contact surfaces must be maintained to ensure they are kept smooth and free from signs of corrosion; this will reduce likely sources of abrasion damage.
- Pedestal and fairlead roller bearing surfaces should be kept lubricated.
- Maintenance of back tension during operation and spooling for inspection must be maintained.
- A more detailed examination should take place after any shock-loading or unusual event. Those involved should compare the condition of the wire to the manufacturer's recommended discard criteria and should check for signs of elongation and bird-caging.

Badly spooled corroded mooring wire

Cargo Wires

Cargo wires are used in cranes, gantries and other cargo lifting appliances. Similar wires will also be used for other lifting operations such as stores cranes and engine room gantries. The comments apply to all such wires used in cargo and other lifting operations.

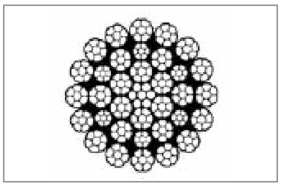
Strength requirements of wire ropes are based on the tensile forces imposed on them by the design of the crane or lifting appliance with an appropriate factor of safety. Applicable safety factors for the wire ropes are set out in the design requirements for cranes and other lifting appliances by various classification societies and are primarily based on the safe working load (SWL) of the equipment. For ship's cranes or other lifting appliances rated between 20 and 60 tonnes (SWL), the required breaking strength of the wire is of the order of four to five times the maximum designed duty load in service. This applies to hoisting and luffing wires, the forces in which alter depending upon the orientation of the crane, jib and the dynamic influences during operation.

Construction

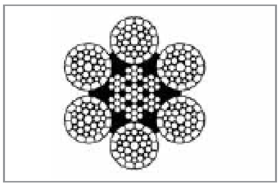
The most common wire construction for wire ropes on ship's cranes or lifting appliances is the 'single layer' wire rope corresponding, as the name suggests, a single layer of strands helically wound around a core. Other types are manufactured such as 'rotation resistant' or 'multi-strand' in which a number of layers of strands are contra-helically wound to reduce the rotational tendency and torque in the rope under tension.

Wire Ropes and Their Uses (cont.)

These ropes can also have 'compacted' strands in which the individual wires are not round but shaped to provide a greater surface area of contact with a sheave and thus reduce the contact pressure.



Cross section of 34 x 7 IWRC low rotation hoist wire   Source: Certex



Cross section of 6 x 36 IWRC crane boom wire showing compacted outer strands.   Source: Certex

Defects and damage

International standard ISO 4309 provides a comprehensive listing of, and photographs, showing a number of defects that can occur on crane or lifting appliance wire ropes. Obvious defects such as kinks and basket deformation in which the external shape of the wire rope changes should be able to be identified relatively quickly. External corrosion should also be obvious during inspection.

Wire ropes should be frequently checked closely for other damage and defects, such as indications of wear (flattening of wires) and broken wires in the strands. The extent of broken wires in a given length and grouping of wire breaks are all factors that need to be considered when judging criteria for allowing the rope to continue in service. Tables in standards set out the relevant criteria although there are differences between the various reference documents and standards under the regulatory requirements in this regard.

Probably the most common defect on wire ropes in which cursory examination of a greased rope can often overlook is wear. This is shown by flattening of the round wire elements. Wear can be accelerated by defective (non-rotating) sheaves with the rope abrading around it or if the wire rope diameter is larger than, and not matched, to the sheaves. Too small diameter sheaves can also result in excessive bending of the rope. Eventually, flattening of the wires reduces the load bearing cross-section of individual wires, which can lead to wire fractures. Wear can also initiate fatigue. From a maintenance and safety perspective of wire ropes, regular inspection and lubrication of sheaves in accordance with the manufacturer's instructions should be followed.

Examples of wear are shown in the two adjacent figures. In one it can be seen by the naked eye that fracture of the wires has commenced due to excessive wear. The scanning electron microscope photograph in the other shows two crack fronts propagating from the flattened portion of the wire through fatigue that ordinarily may not be visible to the naked eye.

According to ISO 4309, a 7% reduction in nominal rope diameter warrants discard of the rope even if no wire breaks are visible.

Whichever guideline document is used to judge condition of a wire rope in use onboard a vessel, it is important to realise that crane or lifting appliance wire ropes should be considered consumable items, which require frequent examination, assessment and maintenance.

Care and handling

There is no set period for the expected lifetime of ropes. However, in practice a survey cycle period of five years would be a typical maximum lifetime for crane or lifting appliance wire ropes. Of course, depending on the duty of the crane or lifting appliance and skill of operators, the hoist wire can be particularly prone to external abrasion or crushing damage. Such damage can occur in a single event and possibly resulting in a relatively new wire to require renewal. A wire, similar to a chain, is only as strong as its weakest point.

Inspection and maintenance

Regular visual inspection, ideally before and after operations handling cargo, should be carried out on board to check for damage and defects. Measurement of the rope diameter (scribed from the circle surrounding the entire rope) should be made and recorded regularly to monitor wear particularly in regions on the rope which regularly passes around sheaves.

Cranes and other lifting appliances and their loose gear, including wire ropes are subject to annual and ordinarily, five yearly surveys, at which they are also proof load tested by the classification society. Details of the surveys are recorded in the vessel's Register of Lifting Appliances and Cargo Handling Gear.

A documentary record of wire ropes in use on the crane or lifting appliances, their identification, appropriate test certificates and dates of renewal should be maintained on board. When wires are delivered to the vessel they must be accompanied with an appropriate certificate setting out the material strength, construction of the rope and breaking load test of a sample.

Wire ropes on cranes or other lifting appliances are exposed to the marine environment and ordinarily a galvanised coating is recommended. Further 'in service' maintenance and protection is also required by regularly lubricating the rope with appropriate grease dressing. In addition to protection from corrosion, the lubricant should penetrate and allow the strands and elements within the rope to move freely relative to each other when their shape changes such as when running around sheaves.

Relevant sources of international standards and guidance

With regard to crane or lifting appliance wire ropes, and guidance on their condition, classification societies commonly refer to guidelines set out by either the International Labour Organization (ILO) or the International Standards Organization (ISO).

Wire Ropes and Their Uses (cont.)

In the practical case of a vessel in port working cargo, the vessel's Flag State and classification society may consider the condition wire ropes with reference to ISO but the port facility may comply with ILO convention C152 - Occupational Safety and Health (Dock Work) Convention 1979 - and/or consider their own national standard to be applicable. In statutory terms, the safety requirements of the cargo handling gear and wire ropes would be governed by the national regulations of the Flag State AND those of the country where the ship's gear is being used.

In the UK, the Health & Safety Commission is the legislative body and its document Approved Code of Practice, Dock Regulations 1988 and guidance also refers to the ILO guidelines. Other countries will also have their own legislative bodies and national standards as appropriate.

Cargo Lashing Wires

Wire is commonly used at sea for securing cargo. The subject will not be dealt with in-depth in this briefing, as detailed guidance on all aspects of the stowage and securing of cargo -including the use of wire ropes - is given in the Association's Loss Prevention Guide entitled Cargo Stowage and Securing.

Typically, a 16 mm diameter, 6 x 12 construction with 7 fibre cores will be used. Such a wire would usually have a minimum breaking strength of approximately 8 tonnes. The construction of the wire, and therefore, its strength, must always be carefully checked to avoid mistakes. As an example, a 16 mm diameter wire rope of 6 x 19 construction with one fibre core might have a breaking strength of 11 tonnes, rather than the 7.7 tonnes of the similar, but softer, 6 x 12 +7FC wire of the same diameter. The size of the wire should always be appropriate to the size and weight of the cargo items being secured and it should also be borne in mind that for ease of use the wire should be flexible (wire of diameter greater than 24 mm and of construction 6 x 37, for example, is not flexible enough for lashing purposes).

Wire does stretch when in use - new wire will initially permanently stretch while it is settling and compacting, and will display an elastic stretch whilst in use, as load increases. The permanent constructional stretch is likely to be between about 0.25% and 1.0% of the length of rope, and the elastic stretch will be up to about 1.0% when the rope is under a load that is close to its nominal breaking load. Thus, when a new wire rope is used to lash a piece of cargo the lashing might stretch by as much as 2% of its original length when subjected to a high loading. For this reason, and because the cargo itself might move a little and settle, lashings must be checked and re-tightened as necessary at intervals throughout the voyage.

Single use and Re-Usable

Because wire will stretch and deform when subjected to high loadings, wire rope used for lashings is considered to be either single use when it is discarded at the end of just one voyage or re-usable when it is not discarded until it is visibly worn but is not exposed to high loadings that would cause weakening.

Details of the loss prevention guide – Cargo Stowage and Securing – can be obtained from the Association's website or the loss prevention department.

Mechanical Pilot Hoists

IMO Resolution MSC.308(88) adopted 3 December 2010 introduced amendments to SOLAS V/23 that prohibit the use of mechanical pilot hoists.

Certification and Regulation

Vessels trading at sea are required to comply with the regulatory requirements of their Flag State. It is common practice for the classification societies to deal with certification on behalf of the Flag State. Individual Flag States are ordinarily members of International Maritime Organization (IMO), an agency of the United Nations, and in the case of the International Convention for the Safety of Life at Sea (SOLAS), all member states are signatories to these common minimum requirements as set out in the SOLAS regulations. Vessels should also adopt industry guidelines and codes of practice.

The International Labour Organisation (ILO) is also an agency of the United Nations. The ILO convention governing the testing, examination, certification and inspection of a vessel's cargo handling gear and crane wires is C152 - Occupational Safety and Health (Dock Work) Convention 1979. The ILO Code of Practice booklet - Safety and Health in Dock Work - includes guidelines on the care and maintenance of wire ropes and includes criteria for their discard. However, the proposals to enhance the health and safety of dock workers and the booklet consider a wide range of aspects regarding cranes and dock work generally. With reference to crane wires, and in particular, the criteria for discard, the booklet could be seen to be rather vague in its stipulations. Over 20 countries have currently ratified the ILO convention but notable exceptions include the UK and USA.

Regulations concerning the testing, certification, thorough examination and inspection of wire rope will be implemented by the competent authorities and organisations appointed by them in accordance with the requirements of ILO Convention 152: articles 21 to 26. The convention requires that wire rope test certificates should include details of:

- The competent person who carried out testing and thorough examination, date, place and signature.
- Name and address of maker or supplier.
- Nominal diameter.
- Number of strands.
- Number of wires per strand.
- Type of core.
- Lay of wire.
- Date of test of sample.
- Quality of wire (N/mm2).
- Load at which sample broke (tonnes).

Wire Ropes and Their Uses (cont.)

- Safe working load of rope (tonnes).
- Intended use.

The International Standards Organisation (ISO) is a non-governmental organisation made up of a network of the national standards institutes of many countries co-ordinated by a central secretariat in Geneva, Switzerland. ISO 4309 - Cranes – Wire ropes – Care, maintenance, installation, examination and discard (currently in its third edition, 2004) - sets out more comprehensive guidelines in comparison with those included in the ILO booklet. It therefore follows that, for the assessment of crane wire ropes on vessels trading internationally, following the guidelines of ISO 4309, which is an excellent reference, should demonstrate an acceptable method of good practice in the international arena.

Sources of International Standards and Guidance

Other useful relevant sources of international standards and guidance include:

General

BS EN 12385:2002 Part 4	Steel wire ropes. Safety. Stranded ropes for general lifting applications
ILO C152: 1979	Occupational Safety and Health (Dock Work) Convention
ISO 2408:2004	Steel wire ropes for general purposes - Minimum requirements
ISO 2532:1974	Steel wire ropes – Vocabulary
ISO 3108:1974	Steel wire ropes for general purpose - Determination of actual breaking load
ISO 3189:1985	Sockets for wire ropes for general purpose Parts 1, 2 and 3
ISO 4345:1988	Steel wire ropes – Fibre main cores – Specification
ISO 4346:1977	Steel wire ropes for general purpose – Lubricants – Basic requirements
ISO 8793:1986	Steel wire ropes – Ferrule secured eye terminations
ISO 17893:2004	Steel wire ropes – Vocabulary, designation and classification
IMCA	Guidance on the Management of Life Cycle Maintenance of Non-Man-Riding Wire Ropes

Pilot Hoist Wires

SOLAS Chapter V/ 23	Pilot Transfer

Accommodation Ladders

ISO 5488:1979	Ships and marine technology – Accommodation ladders
ISO 5489:1986	Ships and marine technology – Embarkation ladders
ISO 7061:1993	Ships and marine technology – Aluminium shore gangways for seagoing vessels
SOLAS Chapter II-1/3-9	Means of embarkation on and disembarkation from ships
MSC.1/Circ.1331	Guidelines for Construction, Installation, Maintenance and Inspection/Survey of Means of Embarkation

Cargo Wires

ISO 4308–1:2003	Cranes and lifting appliances – Selection of wire ropes - Part 1: General
ISO 4308–2:1988	Cranes and lifting appliances - Selection of wire ropes - Part 2: Mobile cranes
ISO 4309:2004	Cranes – Wire ropes – Care, maintenance, installation examination and discard

Elevator Hoist Ropes

BS EN 81-1:1998	Safety rules for the construction and installation of lifts. Electric lifts
ISO 4344:2004	Steel wire ropes for lifts – Minimum requirements
BS EN 12385-5:2002	Steel wire ropes - Safety - Stranded ropes for lifts

Lifeboat Fall Wires

SOLAS Chapter III/20	Operational Readiness, maintenance and inspection
SOLAS Chapter III/36	Instructions for on-board maintenance
SOLAS Chapter IX	
ISM Code, Part 10	Maintenance of ships equipment
IMO MSC.1/Circ.1205	Guidelines for Developing Operation and Maintenance Manuals for Lifeboats
IMO MSC.1/Circ 1206/Rev.1	Measures to Prevent Accidents with Lifeboats
IMO MSC.1/Circ.1392	Guidelines for Evaluation and Replacement of Lifeboat Release and Retrieval Systems

Wire Ropes and Their Uses (cont.)

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6 Brewery Square, Tower Bridge, London, SE1 2LF, United Kingdom.

Telephone: **+44 20 7403 3838.**
Website: **www.brookesbell.com**

Certex UK

Certex UK for their advice and recommendations on wire rope construction and selection.

Certex House, Trafford Court, Doncaster, South Yorkshire, DN1 1PN, United Kingdom.

Telephone: **+44 1302 731000.**
Website: **www.certex.co.uk**

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For more information, please visit www.nepia.com

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