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Lifting Plant (Cargo Handling)

Lifting Plant (Cargo Handling)

CONTENTS

Introduction

Lifting Plant has long played an integral role in the daily operational and functional role of nearly every commercial vessel in service. Incidents and mechanical failures involving shipboard lifting plant, mainly cargo cranes, continue to occur and the causes of these incidents appear to show a number of common failures. Crew and Stevedore injuries and deaths can also be an issue as well as crane failure damage caused by a number of different factors including:-

- corroded wires
- poor quality crane components (materials used)
- poor maintenance regime of shipboard cranes
- poorly trained or inexperienced crews and stevedores operating the cranes
- the bypassing of mandatory safety features of the crane to facilitate faster loading and discharging operations.

When a crane fails this can lead to significant repair costs and lengthy delays leading to commercial disputes, and further expense being experienced by the vessel and owners. As the cranes will be listed as part of the ship's cargo handling arrangement, charterers may use the cranes for loading of discharging cargos and as such any delay in the use of this

equipment due to mechanical failure or poor condition may contribute to a dispute arising. In this briefing we will look specifically at cargo cranes as typically found on geared bulk carriers and general cargo ships.

Definitions of Lifting Plant, Appliances and Lifting Gear

Lifting plant includes lifting appliances and lifting gear.

Lifting appliances means any ships stationary or mobile appliances used for the purpose of suspending, raising, or lowering loads or moving them from one position to another while suspended. It does **not** include:

- Gangways
- Conveyors
- Pipes

Lifting gear means any item by which a load can be attached to a lifting appliance, but does **not** include pallets, pre-slung slings and freight containers.

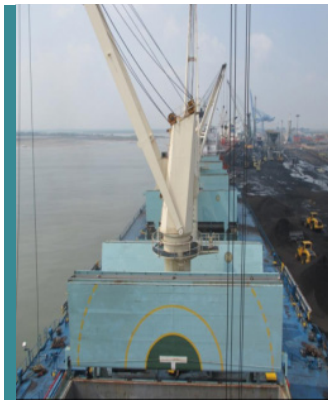
Types of Shipboard Lifting Appliances

There are a number of manufacturers of ship's lifting appliances in the market today who will provide owners with a specific

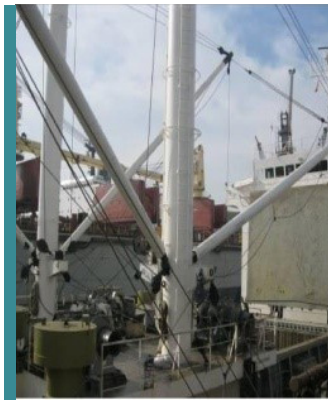
Lifting Plant (Cargo Handling) (cont.)

crane type for a ship's specific. These include lifting plant for cargo handling:

Jib Cranes



Derrick Systems



Gantry cranes

Hose handling cranes

Specialist Heavy Lift Crane

Regulation

A vessel's lifting plant depending on its use may be governed by various international and national rules and regulations as well as other codes and guidance. This may include:

- **International Labour Organisation (ILO)**
  Convention 152. This relates to occupational Safety and Health (dock work), and covers lifting appliances and as such the vessel may be required to carry the "Register of Lifting Appliances and Items of Loose Gear" onboard under article 25 (2) under the convention, or more commonly known as the "Register of Lifting Appliance and Register of Cargo Gear". The register does not make reference to davits and items covered by the LSA Code.
- **International Maritime Organisation (IMO)**
  Safety of Life at Sea 1974 (SOLAS)
  Life Saving appliances Code (LSA)
  Maritime Safety Committee (MSC) Circulars
- **Oil Companies International Marine Forum (OCIMF)**
  SIRE Inspection programme Ships Equipment criteria (Cargo Lifting Equipment 8.9.2)
- **International Safety Guide for Oil Tankers and Terminals (ISGOTT)**
  Section 8.3
- **National Requirements (Flag State)**
  For example, Merchant Shipping & Fishing Vessel (Lifting operation and lifting equipment) Regulations 2006. Guidance is found in the Code of Safe Working Practices for Merchant Seamen (United Kingdom).
- **Classification Society requirements**
  These may be optional or mandatory depending upon the lifting appliance use. Examples of this can be found with the notation assigned by different class societies. For example GLDNV use (LA) for shipboard cranes. Lloyds Register of Shipping has two notations CG optional and LA mandatory; the Class notation of mandatory notation applies when the crane is an essential feature of a vessel for example a diving support vessel, heavy lift vessels and cable layers.

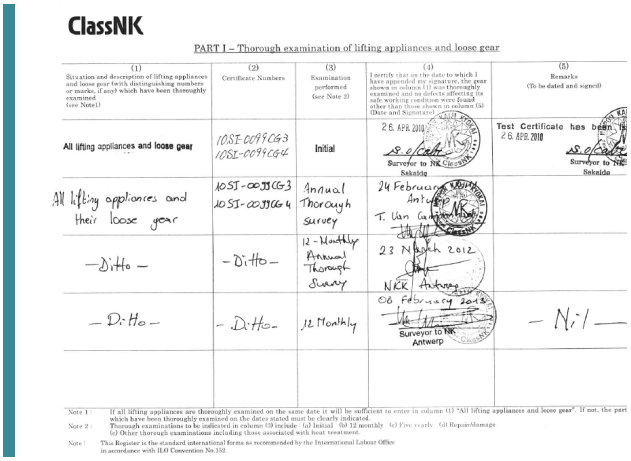
Lifting Plant (Cargo Handling) (cont.)

Inspection and Documentation

Under the "Register of Lifting Appliance and Register of Cargo Gear" required under the ILO Convention 152, the items included onboard should be supplied with a certificate of test and through examination by a competent person prior to being put into service. All certificates for lifting appliances, loose gear and equipment in service should be retained onboard for inspection.

Competent Person

The term ***Competent Person*** is defined as a person possessing the knowledge and experience required for performing thorough examinations and testing of lifting appliances and loose gear and who is acceptable to the competent authority.



ClassNK

PART I – Thorough examination of lifting appliances and loose gear

(1) Situation and description of lifting appliances and loose gear (with distinguishing numbers or marks, if any) which have been thoroughly examined (see Note1)	(2) Certificate Numbers	(3) Examination performed (see Note 2)	(4) I certify that on the date to which I have appended my signature, the gear shown in column (1) was thoroughly examined and no defects affecting its safe working conditions were found other than those shown in column (5) (Date and Signature)	(5) Remarks (To be dated and signed)
All lifting appliances and loose gear	10SI-009CG3 10SI-009CG4	Initial	26 APR 2018 Surveyor to NK Shikoku	Test Certificate has been 26 APR 2018 Surveyor to NK Shikoku
All lifting appliances and their loose gear	10SI-009CG3 10SI-009CG4	Annual Thorough survey	24 February 2012 T. Van Ga... Surveyor to NK Antwerp	
—Ditto—	—Ditto—	12-Monthly Annual Thorough Survey	23 March 2012 NKR Antwerp	
—Ditto—	—Ditto—	12 Monthly	06 February 2013 Surveyor to NK Antwerp	—Nil—

Note 1: If all lifting appliances are thoroughly examined on the same date it will be sufficient to enter in column (1) "All lifting appliances and loose gear". If not, the part which have been thoroughly examined on the dates stated must be clearly indicated.
Note 2: Thorough examinations to be indicated in column (3) include : (a) Initial (b) 12 monthly (c) Five yearly (d) Repair&damage (e) Other thorough examinations including those associated with heat treatment.
Note 3: This Register is the standard international forms as recommended by the International Labour Office in accordance with ILO Convention No.152.

Example of the register of lifting appliances and Register of Cargo Gear

The examination by the competent person should be recorded in the register noting the position, description, safe working load (SWL) and the certification of the item being inspected along with the condition and certificates of wires, ropes and lifting gear.

Testing of Appliances

The register gives guidance on the testing of the lifting appliances SWL. The criteria for the general test for cranes are shown in the following table.

S.W.L	Test Load
Up to 20 Tonnes	25% in excess of the SWL
20 to 50 Tonnes	5 Tonnes in excess of the SWL
Over 50 Tonnes	10% in excess of the SWL

The requirements of the test are as follows:

- The test is to be supervised by a competent person who specifies in writing that the test lift is appropriate in weight and other respects as a test of the lifting plant.
- The competent person is to agree to detailed plan for the lifting test.
- The weight is appropriate proof load, and is known.
- The lift is a straight lift using a single appliance.
- No persons are exposed to danger during the test.

Vessels equipped with a derrick lifting arrangement should be tested at the minimum angle from the horizontal which will be specified by the derrick's manufacturer. The load applied and the minimum angle to which the test load was applied is to be recorded on the test certificate. The test load applied at the minimum angle should be swung as far as possible in both directions.

Responsible Person's Onboard Role

The register should also give a history of the lifting appliances since installation on the vessel detailing maintenance schedules, overhauls, wire changes and any other pertinent information concerning the item being examined. These inspections are usually carried out by the designated ***responsible person*** onboard as appointed by the master. It is the responsible person's job to look after and inspect the items whilst serving onboard. Before any such inspection or maintenance of equipment begins the responsible person should conduct a risk assessment to asses to job hazards and scope of work which is being conducted.

Lifting gear such as strops, chains, shackles, beam clamps, eye bolts, slings, chain blocks, hooks and crane grab buckets to name but a few, should be examined on a periodical basis as stipulated by relevant regulations and manufacturer's guidelines. These should be included into the vessel's planned maintenance system.

Lifting gear can be stored in many areas onboard a vessel depending on the items use and ease to access the equipment quickly either for deck or engine room operations. A catalogue of these items must be kept. Colour coding of items that have recently been tested or inspected and a periodic change of colour coding throughout the year should be encouraged.

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Certification

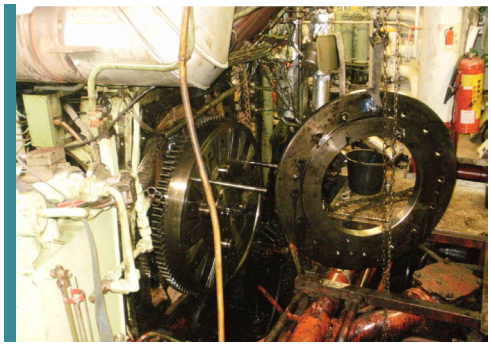
Cranes and other lifting appliances and their lifting gear, including wire ropes are subject to annual and ordinarily, five yearly surveys, at which they are also proof load tested by the classification society. A documentary record of wire ropes in use on the crane or lifting appliances, their identification, 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.

Cargo crane grab bucket

Bow shackels

Strops

If any abnormalities are identified during these inspections such as wear, deformation, fatigue, elongation or corrosion the item should be removed from service and tagged as "unfit for use" or "condemned". An entry should be made in the register of lifting appliance and register of loose gear noting the serial number of the condemned item to be removed from service and the date. Examples of test criteria for loose gear are shown here:



Chain block and strop in use

Item of Lifting Gear	Applied Test Load in Tonnes
Single sheave block	4 x SWL
Multi sheave blocks:	
SWL ≤ 25 tonnes	2 x SWL
25 tonnes ≤ SWL ≤ 160 tonnes	(0.933 X SWL) + 27
SWL > 160 tonnes	1.1 SWL
Chains, hooks,rings,shackles,swivels,etc:	
SWL ≤ 25 tonnes	2 X SWL
SWL > 25 tonnes	(1.22 X SWL) + 20
Lifting beams, Spreaders, Frames,etc:	
SWL ≤ 10 tonnes	2 X SWL
10 tonnes < SWL ≤ 160 tonnes	(1.04 X SWL) + 9.6
SWL > 160 tonnes	1.1 X SWL

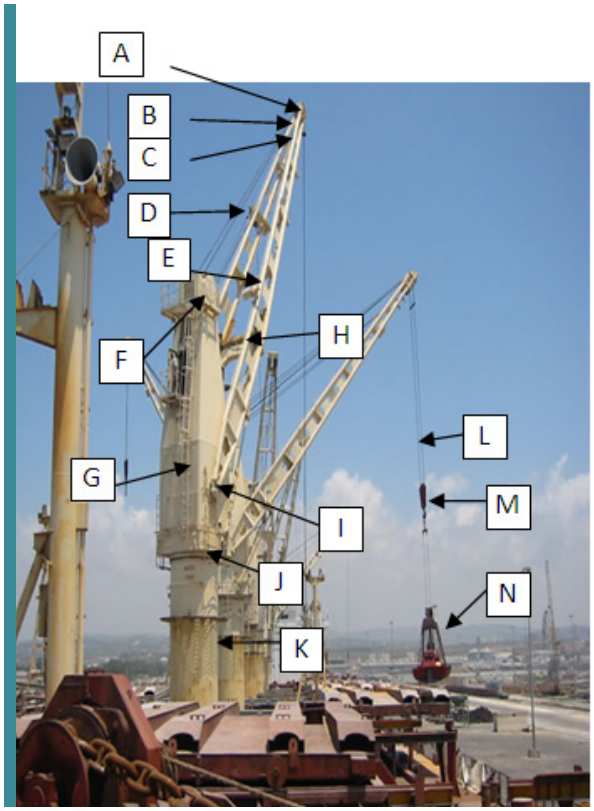
Notes:

1. The SWL for a single sheave block , including single sheave block and beckets,is to be taken as one half of the resultant load on the head fitting.
2. The SWL of a Multi-sheave block is to be taken as the resultant load of the head fitting.

As taken from an extract from the ILO 152 Register of Lifting applainces and register of loose gear test criteria

Lifting Plant (Cargo Handling) (cont.)

Maintenance of Ships Cranes



A. Jib head
B. Jib head sheaves
C. Luffing sheaves
D. Cargo hoist ropes
E. Main jib block
F. Slew Column head sheaves
G. Slew Column upper crane housing
H. Cross member of jib
I. Jib heal incorporating jib heel pin
J. Slew ring bearing
K. Pedestal
L. Cargo hoist ropes
M. Hook block assembly
N. Loose gear attachment (grab bucket)

Planned Maintenance Regimes

There are many moving parts on a crane and their service life can be heavily influenced by the maintenance that is carried out to keep them in good working order. Many vessels, such as geared bulk carriers rely on their cranes to load and discharge cargos and as such components from these should form part of the critical equipment list of spares to be carried. This can be incorporated into the vessels planned maintenance and safety management system (SMS) to identify spares/stock required to be readily available for use.

The vessels planned maintenance system should incorporate the manufacturer's requirements and guidelines on daily, weekly, monthly (frequent basis) and annual, bi-annual and 5 yearly (periodic) schedules of inspection of the crane. Any service bulletins issued by the manufacturer should be studied and incorporated into the planned maintenance regime. All checks should be signed off by the ***Responsible Person*** onboard at the time and a record made of areas of concern for a more detailed inspection or overhaul. For example, a practical schedule might include: (see table below)

EXAMPLE OF A SCHEDULED MAINTENANCE REGIME				
WEEKLY	3 MONTHLY	6 MONTHLY	ANNUAL	5 YEARLY
Grease nipple routines including: winches, sheaves,blocks,slewing ring,derrick heels and other gear.	Inspect chains, hooks, swivels and other subsidiary gear associated with lifting plant and loose items	Overhaul all winches	De-rust, overhaul and paint derricks and other lifting items (Fabric maintenance)	Carry out full overhaul inspection, NDT testing of components, fabric maintenance for rust, corrosion.
	Carry out rocking test on all cargo handling cranes	Derricks and cranes should be stripped of all subsidiary gear, which should be taken apart, inspected, greased and reassembled.	Inspect goose neck swivel, and lift the derrick so it can be overhauled as necessary.	All electrical components checked, tested and replaced as necessary.
	Take and check oil and grease samples	Extract and inspect grease nipples, including grease delivery pipes for obstructions Examine all items to make sure that the SWL and identification mark are clearly visible	New charge for Hydraulic oil tank, and filter cartridge change.	Full test of crane safety cut outs and limit switches prior to being put back into service.

Lifting Plant (Cargo Handling) (cont.)

Pre-Operational Checks Before, During and After Use

- Inspect all equipment, including wire runners and winches. Any suspect component should be replaced immediately with equipment that has suitable certification.
- Inspect and test safety devices prior to use.
- Regularly grease and oil wires, taking care to penetrate the core to prevent internal corrosion.

Crew should familiarise themselves with the types of lifting appliances onboard and be trained in their use. Cranes are high structures so the relevant permits should be issued before any maintenance is carried out. These should include *a task risk assessment* and *working at height permits* and *lock out tag out* at the very least. All personal protective equipment, safety harnesses, communication radio's and tools for the work should be inspected and checked prior to use. It is good practise to hold a pre-job or *"tool box"* discussion by the officer in charge prior to work commencing with the scope of work and precautions to be taken.

Greasing Routines

Greasing routines should be adhered to using the correct grade as specified by the manufacturer. Grease is usually applied using a grease gun, although some cranes are fitted with automatic grease units.

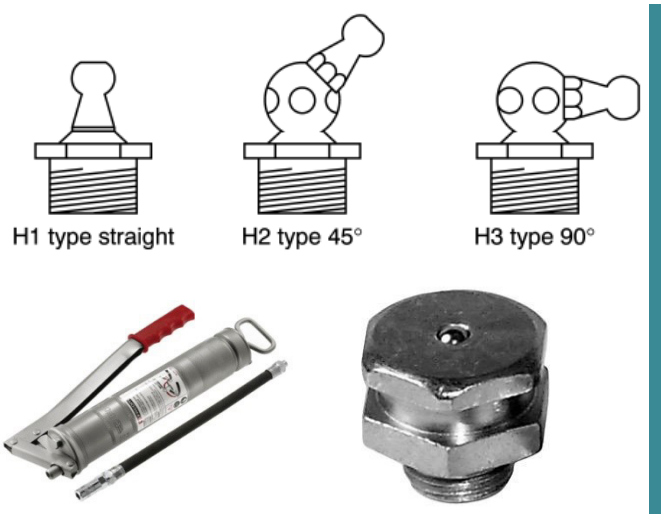
It should be noted that over-greasing can also have a detrimental effect on the crane as well and quantity control should be considered when applying. An example of an automatic greasing unit shown below.

Automatic greasing unit's can be set for a suitable release cycle. Usually they will require change out every three to six months depending on delivery quantity.

With manually applying grease it is vitally important to make sure all greasing points have been completed during the routine, make sure old grease has been removed and a good spread of new grease has been applied and wiping any excess. Grease nipples should be checked to make sure they are in good order, with no paint over the nipple and, no corrosion present.

Environmental conditions where the vessel will be operating during its service life will also have to be considered as hot climates may degrade the grease at a faster rate. In colder climates this may cause delivery pipes or grease to harden giving ineffective lubrication. Manufacturers will state the temperature ranges that grease will give protection and guidance on different grades for hot and cold climates. It is recommended that periodic grease sampling practices are considered to analyze the condition of grease in service.

If any sign of excess pressure is encountered while greasing it can indicate a problem with either the nipple, delivery pipe or grease channels within the unit. These may be clogged with old grease or it could indicate a problem with the component. This should be recorded and investigated as soon as possible. Some cranes have centralised greasing points and the delivery pipes can be quite long before reaching the intended grease application point.



Examples of grease nipples and gun

Apart from a good greasing routine, hydraulic oil samples should be drawn at regular intervals to check for loose particles, water contamination and metal filings which may indicate an issue with the oil which may lead to accelerated wear. Corrosion of internal pumps, hydraulic rams and the cranes overall performance may be effected. Good oil analysis can give an early indication of these issues before a breakdown occurs. All hydraulic hoses, pumps and safety features should be regularly examined and tested to maintain operational performance.

Example of contaminated oil and metal filings on the magnetic drain plug

Lifting Plant (Cargo Handling) (cont.)

Slew Ring

The slew ring bearing is the main load bearing that is connected to the cranes turret and gives the crane the ability to rotate.

The greasing routine for this bearing should be meticulously followed as lack of a good lubrication film will accelerate wear.

The bolts, both internal and external should be regularly inspected according to the manufacturer's instructions to ensure correct torque settings are applied.

A system of lubrication is shown above for the slew ring bearing.

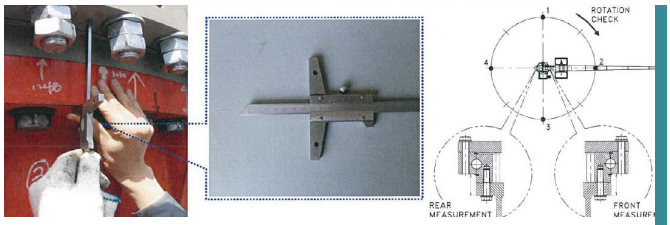
Rocking Test

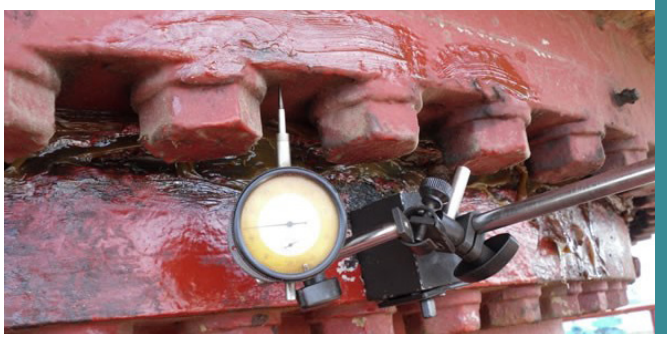
Apart from the greasing routine and bolt inspection of the slew ring a rocking test or tilting test should be carried out on a periodic basis, usually every six months onboard and annually by the competent person or class society.

A rocking test is undertaken to check the wear of the slew ring ball bearings .The test is carried out by referring to the manufacturer's instructions, measurement usually includes taking readings with a clock gauge externally and or internally of the slew ring housing to check for even wear, a note of the backlash measurement between the gear teeth may also be recorded.

A record should be kept onboard to note rates of wear on every cargo crane onboard and identify cranes that may require attention. Manufacturers will state clearance and wear down limits and once the check has been completed onboard they should be checked against the manufacturers prescribed limits. Lubrication, seal integrity and bolting arrangements should be checked. The table shown to the right gives a general indication of wear down limits for a single row ball bearing type racer designed slew ring.

Slew Bearing	Ball Diameter (mm)					
Ball P.C.D	25.4	31.75	34.925	39.688	44.45	50.8
mm	Max allowable deviation in slewing bearing (mm)					
1250 below	1.2	1.2	1.3	1.4	1.5	1.6
1500 below	1.3	1.4	1.4	1.5	1.6	1.7
1750 below		1.6	1.7	2.0	2.1	2.2
2000 below		1.7	1.7	2.0	2.2	2.5
2250 below			1.8	2.0	2.4	2.5
2500 below			1.9	2.1	2.4	2.7





Example of examination with depth gauge and clock guage

The consequences of poor maintenance of the slewing ring can have expensive repercussions in regards to cranes out of service, down time, costly repairs and the vessel unable to meet charter party requirements.

Lifting Plant (Cargo Handling) (cont.)

Rollers retaining ring damaged, rollers displaced.

Slewing bearing inner flange with circumferential deep scoring

The two photographs above show the consequences of poor maintenance, damaged ball bearings and spacers, and surface abrasive wear consistent with under greasing.

Operational Considerations

Safety Devices

It is important for ships crews to understand the types of safety feature which the vessels cranes are fitted with, and why these should be operational and in good working order throughout the service life of the vessel. The safety cut outs are fitted for the safety of those who operate cranes, or are working in the vicinity. Only those trained and competent to do so should operate any lifting appliances. Ship owners and managers should have in place "in house training" for ships personnel by a competent person or provided by a third party company usually the cranes manufacturer or training facility.

There have been many instances of crew and stevedores over-riding safety cut outs to hasten loading and discharging operations. In the short term this may seem a time saving idea, however, in reality it poses an unsafe act in which damage, personal injury and vessel down time can be experienced.

Crane Cab alarm panel

Limit switch box

Safety Device	Remarks
Hydraulic safety valves	Protecting pumps and electrical motors driving, hoisting, luffing and slewing from overload & hydraulic shock loads.
Hoisting Limits	Upper and lower lifting limits including load indicator
Luffing Limits*	Max and Min jib angle and lower jib position *(key for jib resting position) cradle.
Differential limit	Distance limit between hook unit and jib top
Rope slack detector	For hoisting wire rope only
Hydraulic Tank thermostats	Max oil temp control alarm
Starter Interlock	Handle position
Hydraulic tank float switch	Low hydraulic oil level

Loading Characteristics of Ships Crane

It is important for the crew and others assigned who will operate the crane to familiarise themselves with loading characteristics when the crane is in operational service. Every item of lifting gear onboard should have the SWL stencilled, and for the vessels crane it is usually sighted on the jib. It should be noted that the SWL that has been marked on the crane jib is a static load measurement, and when the crane is in operational use the SWL can be exceeded by dynamic loading. Factors to consider should include ships motion whilst hoisting, luffing and slewing in the sea, if loading or discharging from barges or other vessels, taking into account the barges motion in relation to the vessel.

Stowage factor of certain cargos can have an effect on loading/discharging operations using the ships cranes; Iron ore cargos are particularly dense and as such constitute a heavy weight to stow factor. The cranes grab buckets are usually fitted with spill/kick plates to reduce the cubic capacity of the cargo and reduce dynamic loading.

Type of Cargo	Stowage Factor	
	Cu ft/LT	m^3/MT
Iron ore	14	0.4
Grain	45	1.3
Coal	48	1.4
Woodchip	90	2.50

Lifting Plant (Cargo Handling) (cont.)

Example of a static load test using water bags and potential dynamic loading situation from a wet bulk cargo

The crane's manufacturer will supply a load rating and boom angle chart which should be displayed in the cab, however great care and attention should be taken into account for dynamic loading.

It is advised that the use of a pre-use crane checklist be adopted and included into the vessels safety management system detailing risk assessments. A visual inspection and check should be carried out, crane operator's competence, lifting gear attachments such as grab bucket, spreaders, chains, shackles. These should all be correctly connected, secured and verified ready for use.

If the cargo shippers/receivers are employing stevedores companies during loading and discharging operations of the vessels, the officer of the watch should give instruction on the cranes operational limits and safety features prior to use and discuss emergency shutdown procedures and communications. Discharge/loading plans should be agreed and sufficient information and guidance given to crew or stevedores working on deck or in cargo holds. If any member of the crew or stevedore witnesses an unsafe act while the crane is being used, work should stop immediately until the situation can be rectified.

Communications between crane operators and deck personnel is also a critical part of shipboard operations, in the life of the vessel it will operate in many areas of the world where different languages exist and the use of a common language may not always be found.

The IMO have issued a Standard Marine Communication Phrases *IV-C Cargo and Cargo handling guide* and this should be studied and incorporated into the vessels crane operational procedures. Communications should be agreed and a working channel designated and agreed by every participant in the cargo operation.

Cargo loading and discharging can be a 24 hour operation and during the hours of darkness the dangers to personnel working on the vessel deck or cargo holds and in the vicinity of moving cranes can be increased.

The vessel should create a risk assessment to highlight any areas within the working radius of the vessels cranes of poor illumination, any areas noted as having an issue should be addressed to mitigate any potential hazards to crew or stevedore safety.

Wire Rope and Sheaves

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.

Form 4 of the register of lifting appliances and items of loose gear is designated for "certificate of test and through examination of wire rope" within this section all wire rope onboard being utilised in lifting operations should be listed.

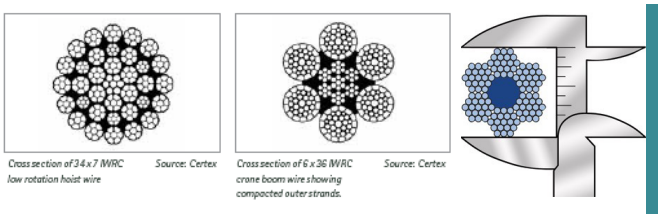
Crane manufacturers will stipulate the type of lay, diameter and SWL properties of the wire to be used on their equipment and this should be rigorously adhered too.

Wire ropes fitted to lifting appliances which are open to the elements will especially suffer corrosion at an increased rate. A good greasing and inspection and maintenance routine is essential to extending the life of the rope, and to check for wear on a regular basis.

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 SWL of the equipment. 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



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*

of layers of strands are contra-helically wound to reduce the rotational tendency and torque in the rope under tension. These ropes can also have 'compacted' strands in which the

Lifting Plant (Cargo Handling) (cont.)

individual wires are not round but shaped to provide a greater surface area of contact with a sheave and thus reduce the contact pressure.

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.

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.

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. A brief guide to wire rope visual checks to be performed is given below:

1. Wear and tear on the outer strands
2. Rust build up or accumulation (static rope and hard to reach areas especially)
3. Twist loosening
4. Reduction in wire diameter
5. Wire and strand fractures
6. Location of the fractures
7. Damage by pinches.

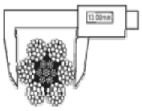
Wire ropes should be frequently checked closely for other damage and defects, such as indications of wear (flattening of wires) and broken wires in the strands. The extent of broken wires in a given length and grouping of wire breaks are all factors that need to be considered when judging criteria for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

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

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 when to discard wires are shown below:

1. WEAR AND TEAR BEYOND 7% OF THE ORIGINAL DIAMETER



2. CORROSION

3. DEFORMATION OF THE WIRE

4. WIRE SHOWS SIGNS OF BUCKLING

5. LOOSENING OF THE INDIVIDUAL WIRES

6. THE APPEARANCE OF THE FORMATION OF KNOTS

7. THE APPEARANCE OF PINCH POINTS

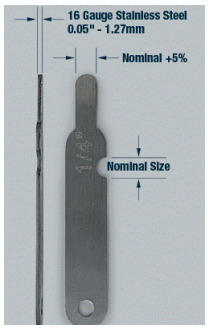
Lifting Plant (Cargo Handling) (cont.)

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

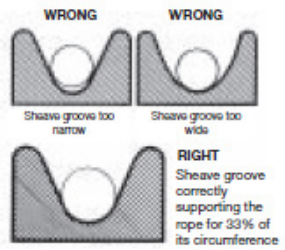
Whichever guideline document is used to judge condition of a wire rope in use onboard a vessel, it is important to realise that crane or lifting appliance wire ropes should be considered consumable items, which require frequent examination, assessment and maintenance.

Sheaves

A cranes wire rope are aligned and fed by guides and sheaves, wire as already discussed can fail due to a number causes. Sheaves and guide can also be a source of a wires failure through abrasive wear and fatigue failures. Wear on sheaves due to excessive loads, poor wire greasing penetration and seizing sheave bearings can lead to frictional loses of the sheave materials where the wire and sheave surface come into contact. The condition of the sheaves and wire guides must be checked at regular intervals to check for wear of the contact surfaces, corrosion, pitting, abrasive and roughness. Sheave grooves are usually hardened to take into account the demands place upon the contact surface; however they will suffer wear eventually and must be examined periodically. A good visual examination with a sheave/wire rope gauge to check tolerances is recommended, also an examination of the root profile on the running surface.



Sheave /rope profile gauge



Sheave groove indicator

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Lifting Plant (Cargo Handling) (cont.)

EXAMPLE OF A TROUBLESHOOTING GUIDE FOR WIRE ROPE	
FAULT	POSSIBLE CAUSE
Accelerated Wear	Severe abrasion from being dragged over the ground or obstructions. Rope not suitable for application. Large Fleet angle Worn sheave with improper grooves, size or shape. Sheaves and followers have rough wear surface. Stiff or seized sheave bearings High bearing and contact pressures. Sheave drum too small.
Rapid appearance of broken wires	Rope not suitable for application. Reverse bends Sheave drum too small Overload or shock loads Excessive rope vibration Kinks have formed and have been straightened out Crushing and flattening of the rope Sheave wobble
Corrosion	Inadequate Lubrication Improper storage Exposure to acids and alkalis
Kinks	Improper instillation Improper hardening Stack rope pulled tight
Excessive localised	Drum crushing Equalizer sheave Vibration

EXAMPLE OF A TROUBLESHOOTING GUIDE FOR WIRE ROPE	
FAULT	POSSIBLE CAUSE
Stretch	Overload Passed normal stretch and approaching failure
Broken wires near fittings	Rope vibration Fittings get pulled too close to sheave or drum
Sheaves and drums wear out	Material too soft
Pinching, crushing oval shape	Sheaves grooves too small Not following proper instillation maintenance procedures on multiple layer drums.
Rope unlays (open up)	Wrong rope construction Rope end attached to swivel
Reduction in Diameter	Broken core Overload Internal wear Corrosion
Bird Cage	Tight sheaves Rope is forced to rotate around its own axis Shock loads Improper wedge socket instillation
Core protrusion	Shock loading Disturbed rope lay Rope unlays Load spins and rotates around its own axis