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Testing of Lifting Equipment (Mobile Crane) as Per Legal Requirements

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Abstract: *This article presents essential inspection and load test methodology for mobile cranes to guarantee safe and efficient operation. It stresses the importance of comprehensive evaluations of various crane parts, such as wire ropes, hydraulic cylinders, and the superstructure, to detect signs of wear, corrosion, and damage.*
In summary, the document acts as a thorough reference for Crane Users and maintenance staff, ensuring legal compliance with all safety protocols and that cranes function within safe limits, thus reducing the likelihood of accidents, and improving the Safety of well-being of all stakeholders and property.
This article comprises best inspection and testing methodologies based on Indian legislation (BoCW Act,1996& The Factories Act,1948), Bureau of Indian Standard (BIS), the International Organisation for Standardization (ISO) and British Standard (BS)..

Keywords: Crane, Safety, Lifting, Load Test, Third Party Inspection (TPI)

I. INTRODUCTION

Legal requirements for load testing of lifting equipment and gears under the Factories Act,1948 and the Building and Other Construction Workers (BoCW) Act,1996 emphasize safety and compliance in the use of such machinery. These regulations mandate regular inspections and testing to ensure that lifting equipment operates safely and effectively, thereby minimizing risks associated with lifting operations. The objectives of the inspection are as follows:

- To ensure the safety of persons and objects against the risk of accidents associated with the general & emergency operation of Mobile Crane
- To ensure that the equipment is in compliance with the appropriate regulations &standards.

Legal Framework:

The Factories Act, 1948: Section 29 mandates that lifting appliances must be thoroughly examined and tested at regular intervals to ensure their safety and reliability.

BoCW Act, 1996: This act requires that all lifting equipment used on construction sites undergo periodic inspections and load testing to comply with safety standards. Reference Section 56. Test and periodical examination of lifting appliances of The BoCW Act,1996

II. LITERATURE REVIEW

Load testing involves assessing the lifting capacity of the equipment to ensure it can handle specified loads without failure. This includes:

The Factories Act, 1948 & The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996 state the requirement of testing Lifting equipment and gears.

Utilizing load sensors to monitor and report on the load conditions (Yunxiao et al., 1994).

Implementing standardized inspection methods to evaluate the performance and safety of lifting machinery (Shan, 2013).

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British Standards

- BS 7121-2-1:2012
- BS 7121-2-3:2012
- ISO 4309:2017
- BS EN 13411-4:2002
- BS EN 13411-5:2003
- BS EN 1677-2:2000

Bureau of Indian Standard IS 13367 (Part1):1992

Who is Competent Person?

Section 2 (ca) defines "Competent Person" for the purposes of carrying out tests, examinations and inspections required by the Factories Act. Such person may be an individual person or an institution. Its recognition by the Chief Inspector is necessary. More than one person or institution can be recognised for a factory. Their qualification, experience and facilities for tests shall be considered by the Chief Inspector before recognising them

'Competent person' may be recognised for the purposes of carrying out tests, examinations, inspections and certification for such buildings, dangerous machinery, hoists and lifts, lifting machines and tackles, pressure plant, confined space, ventilation system and such other process or plant and equipment as stipulated in the Act and the rules made there under. The person should be physically fit to carry out such tests etc and should not be above the age of 62 years.

Section	Description
28	Lift & Hoist
29	Lifting Machines, tackles
6 R 112	Structural Stability of building, plant
31	Pressure plant
36	Percussion against Dangerous Fumes
41, 112	Ship Building,Repair,Breaking
87	Ventilating System
21	Dangerous Machines

Inspection Procedure:

Tools and Equipment required for inspection: The inspection kit of Competent Person should comprise:

- Vernier Calliper
- Measuring Tape
- Spirit Level Meter
- Anemometer
- Angle Indicator
- Sheeve Gauge
- Calibrated Test Weight for Load Testing
- PPE

Documentation (Pre-Inspection Checks): During the inspection, first the Competent Personmust look for:

- Machine third-party certificate
- Operator's License/ Competency Certificate
- Third Party Certification of Lifting Accessories
- Manufacturer manual
- Maintenance Logbook
- Registration card (if any)

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Traceability: Competent Personmust note down and check the following:

- Registration plate Number (if any)
- Chassis Number
- Model of the machine
- Year of manufacture
- Engine serial number
- Capacity

Site Assessment: Check the condition of the surroundings and provide barricades around the machine.

Visual & Functional Inspection: Items to be check during the thorough examination of mobile carne during visual & functional inspection:

- Visually examine the tires for wear, damage and inflation pressure.
- Visually examine the crawler tracks for wear and adjustment.
- Visually examine the crane structure, including the chassis, for signs of damage, distortion, cracking and corrosion.
- Visually inspect all bolts and fastenings to check that they are not coming loose.
- Visually examine the slewing mechanism for safety and wear during operation of the slew motion throughout its full range of movement and with the crane at maximum reach.
- Examine all hydraulic cylinders for leakage, corrosion on the rods and alignment. Visually check end fixings for wear, safety and lubrication.
- Visually inspect the superstructure and jib of the crane for corrosion, damage, cracks and distortion.
- Visually examine all pivoting joints on the jib and attachments of the crane for wear, corrosion, safety and evidence of lubrication.
- Operate telescoping extensions on the crane and visually examine them for wear and safety.
- Visually examine all wire ropes to determine whether they are of the size and type specified in the instructions and reeved in accordance with those instructions. Pay particular attention to the end terminations.
- Visually check whether all pulleys/sheaves and drums are free from damage and wear, whether the rope fits correctly on them and if they are effectively lubricated. Check whether all idler pulleys/sheaves turn freely and that all guards are undamaged and in place.
- Thoroughly examine the entire length of wire ropes for signs of wear, damage, broken wires and corrosion.
- Visually inspect the barking mechanism for wear, damage and adjustment and check whether it conforms to the instructions for the crane.
- Check the oil and other fluids for condition (for e.g. By debris monitoring) and level of the fluid.
- Visually check whether the fixings for the operator's seat, where fitted, and restraint are all in place and secure.
- Check whether all control levers are marked with their function and mode of operation.
- Visually inspect the upper and lower hoist limit switches, check if they are in place and free from damage and excessive wear.
- Visually examine the hooks, their attachments and safety catches for wear, fretting, distortion, corrosion and safety.
- Visually examine the fly jib and mounting attachment for corrosion, cracking, distortion and wear. Check whether the hoist limit switch is in good working order.
- Check whether there is a table displayed in the operator's cabin showing the rated capabilities for the mobile crane for all crane operating conditions (free on wheels, free on cushion wheels, all permitted outriggers position etc.

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- Functionally test all controls for smoothness of operation and to determine whether they are free from wear and other damage.
- Check whether warning signs and other important instruction are present and readable, for example rating plate for load lifting.
- Operate the mobile crane to check whether all motions operate smoothly and effectively without excessive play. The load lifting attachment should not drop excessively after the motion has been stopped and all limiters and safety devices should operate correctly.
- Check ASLI (Automatic Safe Load Indicator) is calibrated and working correctly.

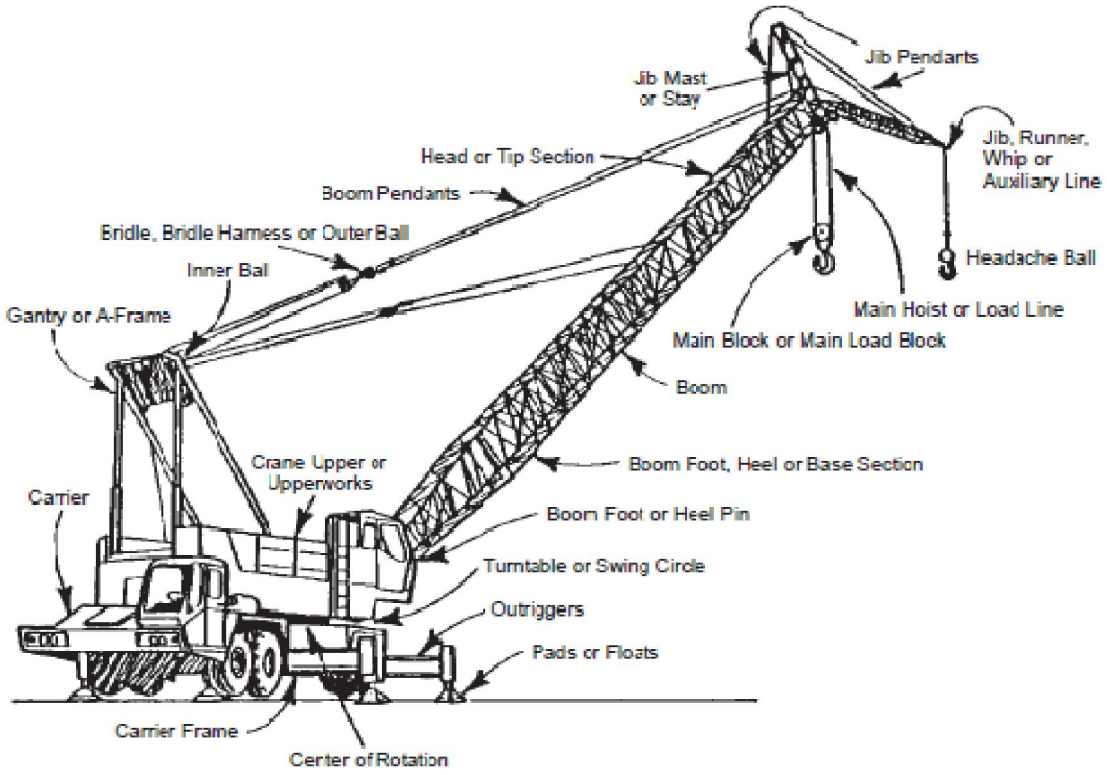

FIG-1: PARTS NAME OF LATTICE BOOM CRANE

Loads Test:

As per BoCW Act, 1996, the following is the criteria to conduct load test of Lifting Appliance & Lifting Gear:

1. Lifting Appliance

Every lifting appliance with its accessory gear, shall be subjected to a test load which shall exceed the safe working load (SWL) as specified in the following table:

Safe Working Load	Test Load
Up to 20 tonnes	25% in excess of safe working load
Up to 50 tonnes	5 tonnes in excess of safe working load
Over 50 tonnes	10% in excess of safe working load

-The test load shall be lifted and swung, as far as possible, in both directions. If the jib or boom of the crane has a variable radius, it shall be tested with test loads at the maximum and the minimum radii. In the case of hydraulic cranes

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when owing to the limitation of pressure, it is impossible to lift a test load in accordance with the above table, it will be sufficient to lift the greatest possible load which shall be more than safe working load.
-The test shall be performed at maximum/ minimum and intermediate radius points as well as such points in the arc of rotation as the competent person may decide. The test shall consist of hoisting, lowering, breaking, and swinging through all positions and operations normally performed. An additional test shall be made by operating the machinery at maximum working speed with the SWL suspended.

Use of spring or hydraulic balances, etc. for the test loading: All tests shall normally be carried on with the help of dead weights. In the use of periodical tests, replacements, or renewals, test load may be applied by means of suitable springs or hydraulic balances. In such case, test load shall be applied with the boom as out as practicable in both directions. The test shall not be taken as satisfactory unless the balance has been certified for accuracy by the competent authority within 2.0 % and the pointer of the machine has remained constant at the test load for at least five minutes.

Testing machine and dead weights.

- A suitable testing machine shall be used for testing of chains, wire ropes, and other lifting gears.
- Testing machines and balances to be used in test loading, testing, and checking shall not be used unless they have been certified for accuracy at least once in the proceeding 12 months by the competent authority.
- Moveable weights used for the test loading of the lifting appliances having a safe working load not exceeding 20 tones shall be checked for accuracy by means of suitable weighing machine of certified accuracy

Through examination after testing or test loading: After testing or test loaded, every lifting appliance and associated gear shall be thoroughly examined to see that no part has been damaged or permanently deformed during the test. For this purpose, the lifting appliance or gear shall be dismantled to the extent considered necessary by the competent person.

2. Lifting Gear

Every ring, hook, chain, shackle, swivel, eyebolt, plate clamp, triangular plate or pulley block (except single sheave block) shall be subjected to a test load which shall not be less than the load as specified in the following table:

Safe Working Load	Test Load (in tonnes)
Up to 25 tonnes	2 x Safe Working Load
Over 25 tonnes	(1.22 x Safe Working Load) + 20

In the case of a single sheave block, the safe working load shall be the maximum load which can safely be lifted by the block when suspended by its head fitting and the load is attached to a rope which passes around the sheave of the block and a test load not less than four times the proposed safe working load shall be applied to the head of the block.

In the case of a multi sheave block, the test load shall not be less than the load as specified in the following table:

Safe Working Load	Test Load (in tonnes)
Up to 25 tonnes	2 x Safe Working Load
25 tonnes to 160 tonnes	(0.9933 x Safe Working Load) + 27
Over 160 tonnes	1.1 x safe working load

In the case of hand-operated pulley blocks used with pitched chains and rings, hooks, shackles or swivels, permanently attached thereto, a test load not less than 50 per cent in excess of the safe working load shall be applied.

In the case of a pulley block fitted with a bucket, the bucket shall be tested and the load applied to the bucket when testing that block will be accepted as test load of the bucket.

In the case of a sling having two legs, the safe working load shall be calculated when the angle between the legs is 90 degrees. In case of multi-legged slings, the safe working load shall be calculated as per national standards.

Every lifting beam, lifting, frame, container spreader, bucket, tub, or other similar devices shall be subjected to a test load which shall not be less than the load as specified in the following table:

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Proposed Safe Working Load	Test Load (in tonnes)
Up to 10 tonnes	2 x Safe Working Load
10 tonnes to 160 tonnes	(1.04 x Safe Working Load) + 9.6
Over 160 tonnes	x safe working load

Load test criteria for lifting tools & tackles:

Lifting & hoisting machinery including all parts and necessary gear whether fixed or movable before being taken into use shall be tested and examined by a competent person for specified ratings and for safe operation at least once in twelve months and shall be re-tested and re-examined after any substantial alteration or repair.

Overload Test Guidelines:

- Before and after any overload testing the crane should be thoroughly examined. The objective of overload testing is to determine whether the crane is stable, structurally sound and fit for the use for which it was designed.
- The instructions and other relevant information provided by the manufacturer or other appropriate specialist should be followed prior to the application of overloads to the crane.
- Overloads should be kept as close to the ground as possible, generally between 100 mm and 200 mm. preferably, overloads should not be raised above 200 mm to allow them to pass over obstructions.
- Overload testing should also include the functional and calibration check of **ASLI**.

Hoist brake operational test:

This test should be carried out to check the operational efficiency of the hoist brake. In addition to the test supporting a thorough examination, this test should also be completed following a major overhaul of the braking system, replacement of brake shoes or pads, or if the brake has failed to arrest or hold a load.

The operational test should include:

- Dynamic testing to check that the brake can bring to rest a moving load being lifted or lowered at the normal maximum operational speed.
- Dynamic testing to check that the brake can bring to rest a moving load being lifted or lowered at the normal maximum operational speed following the operation of the emergency stop.
- Static testing to check that the brake can hold a static load without slippage.

Automatic Safe Load Indicator (ASLI) calibration checks and functional tests:

During the calibration check of the ASLI, it is essential that the crane is not loaded beyond its rated capacity of 110% or Original Manufacturer's recommendation. The ASLI should be subjected to a functional test and should give the following warnings within the tolerance limits stated.

- **Warning of approach to rated capacity:** The ASLI should give a clear and continuous warning of the approach to the rated capacity. The warning should commence at a load of not less than 90% of the rated capacity and not more than 97.5%. The approach to rated capacity warning should continue to function until the load as a percentage of rated capacity falls to below the value at which the warning was initiated.

Other Inspection &Checks:

Hook Block Inspection:

The inspection of hook blocks should assess the general condition of the assembly and the condition of bearings and fasteners. The mouth of the load hook should be checked for deformation by measuring between the marked datum points and comparing the value obtained with the original dimensions marked on the hook data plate. The increase should not exceed the value specified by the manufacturer (normally 10%).

Sheaves Check:

Sheaves should be checked as part of testing in support of thorough examination, and frequently between thorough examinations, to determine whether they rotate freely and whether any play in the bearings is within the manufacturer's

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limits. The radius at the bottom of the sheave groove should be checked with a set of sheave gauges to determine whether it is within the manufacturer's limits. These limits are normally no smaller than the nominal rope diameter +5% and no greater than the nominal rope diameter +15%.

Wire Rope Winches (Drums) Inspection:

The following checks need to be done while inspecting wire rope winches:

- Minimum number of turns on the drum as per manufacturer manual.
- There should be no excessive play in the drums.
- Should be no signs of corrosion, wear, cracks.
- The depth of groove must be as per manufacturer manual (normally at 1/3 times of wire rope dia.)

Wire Rope Terminations:

For wedge socket extreme care must be exercised when installing rotation resistant ropes, and here in the pictures we have the correct ways for installing a wedge socket because attaching the dead end to the live line can damage the live line, and may the load being transferred to the dead end, beside that you must be sure the socket, wedge and pin are the correct size for the wire rope used.

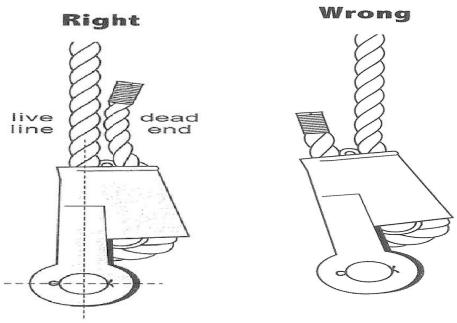

FIG-2: WEDGE SOCKET TERMINATION

Assessment Of Wire Rope Condition and Discard Criteria: Following is the assessment and discard criteria of wire rope:

Visible Broken Wires:

- Two or more broken wires in rope lay length (approx. equal to the length of 6d)
- Two or more broken wires at a termination
- If localized grouping of broken wires is concentrated in one or two neighbouringstrands, it might be necessary to discard the rope.

Uniform Decrease in Wire Rope Dia.:

- The discard criteria value for uniform decrease for the sections of rope of rotation resistant rope is **5% and over.**

Corrosion:

- When externally corroded, wire surface heavily pitted and slack wires must be discarded immediately.
- Obvious visible signs of internal corrosion i.e. corrosion debris exuding from the valleys between outer strands.

Waviness:

The rope must be deemed unsuitable for use if, under any circumstances, either of the subsequent conditions is present: In the case of a linear section of rope that does not pass through or around a sheave nor spool onto the drum, the distance between a straightedge and the inferior surface of the helix is equal to or exceeds 1/3 times the diameter (d).

In instances where the rope traverses a sheave or is wound onto the drum, the distance between a straightedge and the inferior surface of the helix is equal to or greater than 1/10 times the diameter (d).

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Local Increase in Dia.: If the rope dia. Increases by 5% or more for a rope with a steel core or 10% or more for a rope with a fiber core shall be discarded.

Other Discard Criteria of Wire Rope are:

- Basket Deformation
- Core or strand protrusion.
- Flattened portion.
- Kinks
- Bend in rope
- Damage due to heat.

Non-Destructive Testing (NDT):NDT should be carried out if a Competent Personhas a doubt on the welding areas of the crane to check the strength and cracks.

Report & Certification:

When deficiencies which directly affect operating safety are found, the Competent Person will immediately notify the client, and the certificate will be withheld until corrective action is taken.

When no deficiencies have been found, the Competent Person will complete and sign a Mobile Crane test certificate according to State Factory Rules.

Provisional Operation Permit: This permit is stamped and issued by a Competent Person immediately, allowing operations to continue after a third-party inspection has been conducted and passed the criteria but before the official Third-Party Inspection (TPI) certificate is issued.

Importance of Compliance

Regular load testing is crucial for preventing accidents and ensuring the safety of workers. Non-compliance can lead to severe consequences, including legal penalties and increased risk of workplace injuries.

Conversely, while the legal frameworks provide a foundation for safety, the ambiguity in inspection regulations can lead to inconsistent practices across different sites, potentially undermining the effectiveness of these safety measures (Shan, 2013).

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