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Code of practice for the safe use of cranes

Part 2-4: Inspection, maintenance and thorough examination – Loader cranes

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Foreword

Publishing information

This sub-part of BS 7121-2 is published by BSI Standards Limited, under license from the British Standards Institution and came into effect on 31 July 2013. It was prepared by Subcommittee MHE/3/11, *Crane safety and testing*, under the authority of Technical Committee MHE/3, *Cranes and derricks*. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession

Together with BS 7121-2-1, BS 7121-2-3, BS 7121-2-5 and BS 7121-2-7, this sub-part of BS 7121-2 supersedes BS 7121-2:2003, which will be withdrawn when all these sub-parts have been published.

Relationship with other publications

The BS 7121 series is being revised. The following new sub-parts of BS 7121-2 have been published or are in preparation.

- Part 2-1: *Inspection, maintenance and thorough examination – General;*
- Part 2-3: *Inspection, maintenance and thorough examination – Mobile cranes;*
- Part 2-4: *Inspection, maintenance and thorough examination – Loader cranes;*
- Part 2-5: *Inspection, maintenance and thorough examination – Tower cranes;*
- Part 2-7: *Inspection, maintenance and thorough examination – Overhead travelling cranes including portal and semi-portal cranes, hoists, and their supporting structures;*
- Part 2-9: *Inspection, maintenance and thorough examination – Cargo handling and container cranes*.

When all sub-parts of BS 7121-2 have been published, it is intended that CP 3010 will be withdrawn and BS 5744 will be revised to cover manually operated and light cranes only.

This sub-part of BS 7121-2 is intended to be used in conjunction with BS 7121-2-1.

Information about this document

The Health and Safety Executive (HSE) commends the use of this British Standard to those who have duties under the Health and Safety at Work etc. Act 1974 [1]. This standard was drawn up with the participation of HSE representatives and it will be referred to in the relevant HSE publications.

The BS 7121-2 series has been accepted by the HSE as representing the consensus of opinion based on practical experience for safety of cranes.

Hazard warnings

WARNING. This British Standard calls for the use of procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

As a code of practice, this sub-part of BS 7121-2 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this sub-part of BS 7121-2 is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Particular attention is drawn to the following specific regulations:

- Health and Safety at Work etc. Act 1974 [1];
- Lifting Operations and Lifting Equipment Regulations (LOLER) 1998 [2];
- Provision and Use of Work Equipment Regulations (PUWER) 1998 [3];
- Supply of Machinery (Safety) Regulations 2008 (as amended) [4];
- Road Vehicles (Construction and Use) Regulations 1986 (as amended) [5];
- Road Traffic Act 1991 [6];
- Work at Height Regulations 2005 (as amended) [7].

NOTE Details of the Lifting Operations and Lifting Equipment Regulations 1998 [2] and the Provision and Use of Work Equipment Regulations 1998 [3], together with an HSE Approved Code of Practice and HSE Guidance, are given in HSE publications Safe use of lifting equipment *[8] and* Safe use of work equipment *[9].*

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Introduction

Loader cranes have traditionally been used to load and unload vehicles on which they are mounted, These vehicles, complete with the crane, being referred to as "lorry loaders". Increasingly loader cranes are being used in place of mobile or overhead cranes.

Loader cranes can be installed in a static location, for instance on a quay, in a factory or on the roof of a building.

1 Scope

This sub-part of BS 7121-2 gives recommendations for the pre-use checks, in-service inspection, maintenance, thorough examination (in service and following exceptional circumstances) and supplementary testing of loader cranes.

This sub-part of BS 7121-2 also covers lifting accessories, attachments and interchangeable equipment that may be used in conjunction with loader cranes, such as brick grabs, muck grabs, augers, clamshells, pallet forks, wire rope hoists, fly jibs, magnets, vacuum lifters, manipulators, integrated man baskets and spreaders.

This sub-part of BS 7121-2 is applicable both to lorry loaders and to loader cranes used in other situations.

This sub-part of BS 7121-2 does not cover the stability testing and certification immediately following installation of loaders cranes on vehicles, or in static locations. This is covered by BS EN 12999.

This sub-part of BS 7121-2 is not applicable to lorry loaders or loader cranes on marine and other water-borne vessels.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7121-2-1:2012, *Code of practice for safe use of cranes – Part 2-1: Inspection, maintenance and thorough examination – General*

BS ISO 4309:2010, *Cranes – Wire ropes – Care and maintenance, inspection and discard*

3 Terms and definitions

For the purposes of this sub-part of BS 7121-2, the terms and definitions apply given in BS 7121-2-1:2012 and the following apply.

3.1 loader crane
powered crane comprising a column which slews about a base, and a boom system which is attached onto the top of the column

3.2 lorry loader
commercial vehicle or trailer, fitted with a loader crane, which normally has a load-carrying capability

4 General

Regular pre-use checking, in-service inspection, maintenance and thorough examination of cranes are essential if cranes are to function safely and reliably. The nature of these activities can be summarized as follows.

- Pre-use checks are visual checks which are carried out to ensure that the crane has not suffered any damage or failure, and is safe to use.
- In-service inspections and maintenance are carried out to ensure that components are repaired or replaced before they deteriorate to a point at which they would become unsafe.
- Thorough examinations are carried out at specified intervals, after installation on a new site, after major alteration or repair or after the occurrence of exceptional circumstances which could jeopardize the safety of the crane.
- Supplementary testing is carried out in support of thorough examination and the extent and nature of any testing are specified by the competent person carrying out the thorough examination.

5 Personnel carrying out pre-use checks, in-service inspections, maintenance and thorough examinations

Attributes, competencies, competency assessment, training plans and training records of personnel should be in accordance with BS 7121-2-1:2012, Clause **5**.

6 Pre-use checks and in-service inspections

6.1 General

Pre-use checks and in-service inspection of cranes, together with a system to rectify any defects disclosed, are required by the Health and Safety at Work etc. Act 1974 [1] Section 2(2)(a), and LOLER 1998 [2] Regulation 9(3)(b) to ensure that the crane is safe to use and that any deterioration is detected and rectified before the crane becomes unsafe.

Pre-use checks and in-service inspections should only be carried out by personnel who have been adequately trained and assessed as competent to carry out the required tasks (see Clause **5**). LOLER 1998 [2] requires that results of all in-service inspections are recorded in writing. It is recommended that the results of all pre-use checks are also recorded in writing.

The crane user should ensure that sufficient time is allowed for pre-use checks to be carried before the crane starts work. The user should also ensure that a safe system of work is in place to prevent the person who is carrying out the checks/inspections from being exposed to danger.

6.2 Pre-use checks

Pre-use checks should be carried out at the start of each shift during which the crane is to be used and at each change of operator. These are to test the functionality of the crane and visually check for any obvious defects. It is essential that these are carried out from a position of safety.

An example of a checklist for pre-use checking of a loader crane and of a lorry loader is given in Annex A.

6.3 In-service inspection

A regular in-service inspection should be made to identify any defects which might not be detected by the pre-use checks. In-service inspections should be carried out at intervals which ensure that any deterioration is identified before there is a risk of failure of the crane or injury to persons. Further guidance is given in HSE document L113 [8]. It might be convenient to schedule the inspections concurrently with planned preventive maintenance (see BS 7121-2-1:2012, **7.2.2** and **7.2.3**).

For loader cranes, two types of in-service inspection should usually carried out. The first, which is in addition to the pre-use checks, should be carried out at intervals of between 1 week and 1 month, depending on the application and level of use of the crane. An example of a checklist for this type of in-service inspection is given in Annex B. The second type of in-service inspection should be carried out at intervals of between 3 months and 6 months. An example of a checklist for this type of inspection is given in Annex C.

An example of an in-service inspection checklist for an attachment is given in Annex D.

Steel structures suffer from fatigue, a process which can create cracks that propagate over time. If left unattended, cracks can cause serious failure of the crane structure. The in-service inspection regime should include measures to detect cracks before the safety of the crane is affected. Therefore, in-service inspections should include a structural inspection of highly stressed areas of the crane. Details of these areas are given in Annex E.

NOTE The majority of these areas are adjacent to greasing points so a close inspection can be made while the structure is being lubricated.

If there are any indications of cracking or excessive wear in pins, bearings or structural components, the crane should be taken out of use and a thorough examination should be carried out in accordance with Clause **8**, with NDT if considered necessary by the competent person.

The period between inspections should be decided on the basis the duty of the crane and the environmental conditions. The period should be kept under review and adjusted according to the results of the inspections.

6.4 Reporting of defects

LOLER 1998 [2] requires that defects be reported immediately they are identified. There should be provision for the personnel carrying out pre-use checks or in-service inspections to make written reports of defects or observations immediately they are identified.

This facility should augment the normal verbal reporting that should routinely take place between crane operator and crane owner/site manager. The written report should be to a pre-defined format, (a company pro-forma, a section on the daily time sheet, etc.), which requests details of the defect or observation and supporting information such as date, time, crane identification, error codes and circumstances. The operator should also fill in a written report when there are no defects or observations to report (a "nil report") and these should be submitted at least weekly.

All the defect reports, including the "nil reports", should be forwarded to the crane owner, (or the crane owner's delegated representative), who should arrange for any necessary action to be taken on the basis of the report. A copy of the original report should be retained by the crane user.

Once the defect/observation has been dealt with and cleared this should then be recorded with supporting information on the original defect report.

The "cleared" reports should be securely lodged in the crane owning company's maintenance management system and should be made available on demand to the users of the crane as well as other authorized bodies.

6.5 Records of pre-use checks and in-service inspections

6.5.1 General

Written records of all pre-use checks and in-service inspections should be kept.

6.5.2 Pre-use checks

The record of a pre-use check should include at least the following information:

- identity of the crane;
- date of inspection;
- result of the check, i.e. whether or not the crane passed;
- name and signature of person carrying out the check.

This may be recorded by, for example, completing a standard pro-forma record.

6.5.3 In-service inspections

The record of an in-service inspection should include at least the following information:

- date and location of the inspection;
- description and unique identification number of the equipment inspected;
- nature and extent of the inspection;
- results of the inspection, including details of the condition of critical components which need to be monitored, for example a wire rope showing signs of wear;
- name and signature of person carrying out the inspection.

The record should be related to the crane's historical records and made available to the competent person responsible for the thorough examination (see Clause **8**).

6.6 Inspection of second-hand loader cranes

When purchasing second-hand loader cranes their condition should be inspected and assessed; nothing should be taken for granted. Second-hand cranes might contain latent defects which might otherwise only become apparent when the machine is put into service. They might have suffered significant damage and have been inadequately repaired. Second-hand cranes might also have been imported into the European Community without being modified to meet EU requirements, so called "Grey imports".

The assessment of a second-hand crane should include a review of maintenance records and previous reports of thorough examination, together with consultation of the manufacturer to obtain details of any major repairs, etc. The contents of any data logger should be downloaded and reviewed. The assessment might require the removal of access covers or stripdown of major assemblies to reveal parts that could not ordinarily be seen. Once the crane's condition has been fully assessed any necessary repairs should be carried out and appropriate inspection and maintenance intervals established.

7 Maintenance of loader cranes

7.1 General

Under the Provision and Use of Work Equipment Regulations (PUWER) 1998 [3] employers are required to ensure that cranes are maintained in an efficient state, in efficient working order and in good repair. To ensure adequate maintenance an effective maintenance management system should be set up in accordance with BS 7121-2-1:2012, **7.1**.

7.2 Maintenance intervals

7.2.1 General

The Health and Safety at Work etc. Act 1974 [1] sets out a general duty requiring that work equipment is maintained so that it is safe.

For loader cranes, planned preventive maintenance (see BS 7121-2-1:2012, **7.2.2** and **7.2.3**) should be carried out at intervals which ensure that worn and damaged components are renewed before the loader crane becomes unsafe, breaks down or fails.

NOTE Breakdown causes downtime and a consequent loss of production for the user, whilst a component failure could result in a partial or total collapse of the crane with potentially fatal consequences for persons in the vicinity.

7.2.2 In-service maintenance interval

A loader crane should be maintained at regular intervals to avoid breakdown, failure or collapse. The frequency at which inspection and maintenance is carried out should be based on the recommendations contained in the manufacturer's manual for the loader crane. This should however generally be taken as the maximum interval as various factors, including the following, might require the interval to be reduced.

- *Usage* – The number of hours and/or cycles of operation and the type of loading to which the crane has been subjected. Frequent lifting at or near the rated capacity which might accelerate wear of all components. Additional loads that might arise from the use of attachments (e.g. muck grabs, brick grabs and pole grabs).
- *Environment* – Handling of corrosive materials or exposure to extreme weather which might accelerate corrosion of structural components, fasteners and wire ropes.
- *Feedback* – Feedback from maintenance records and thorough examination reports which might indicate accelerated rates of wear and deterioration.
- *Age* – The crane structure and components might be subject to deterioration with age and additional maintenance might be required.

Once established the inspection and maintenance interval should be recorded in the machine history file (see **7.5**). It is essential that any variation from the manufacturer's recommended intervals is recorded and justified each time a change is made.

7.2.3 Maintenance of cranes that remain in service past their design life

Most loader cranes are likely to have been designed to a standard that includes an in-service design life, typically based on fatigue. Loader cranes manufactured prior to 2004 will most probably have been designed to DIN 15018-1, whilst loader cranes manufactured after 2004 are likely to have been designed to BS EN 13001. If a crane is to be used past the original design life, then at the end of the original design life an assessment of additional life expectancy should be undertaken in which an assessment is made of the integrity of the crane and its suitability to operate for a defined additional time period or number of load cycles. The person undertaking this assessment should take account of the crane operation, maintenance and thorough examination history. If the original design life of the crane cannot be obtained from the original manufacturer, or insufficient information is available from current or previous owners, then this assessment should be undertaken when the crane is 8 years old.

Loader cranes manufactured to BS EN 13001 are likely to have a data logging function in the RCI/RCL to record load collectives (which are a function of the numbers of load cycles and their intensity in terms of loading), from which the remaining life expectancy can be calculated. The crane owner should contact the crane manufacturer or authorized service agent to have this information downloaded from the RCI/RCL and a report compiled.

NOTE As there is a considerable overlap period for transition between DIN 15018-1 and BS EN 13001, depending on the manufacturer of the loader crane, owners should consult the manufacturer of their particular loader crane to find out to which standard it has been designed.

For a crane that is to be used past the original design life, on completion of the assessment of additional life expectancy, the maintenance plan for the crane should be amended to take account of the findings of the assessment. The findings of the assessment should be provided to the competent person responsible for preparing the defined scope of thorough examination (see **8.5**).

7.3 Information for maintenance

The wide variation of designs and the increasing complexity of loader crane technology make it essential that all maintenance personnel are supplied with adequate information to enable them to carry out their duties effectively and safely. The recommendations given in BS 7121-2-1:2012, **7.8** should be followed.

7.4 Inspection during maintenance

This inspection is normally undertaken by maintenance personnel and is in addition to the in-service inspections undertaken in accordance with Clause **6**.

When inspections are being carried out as part of maintenance it is important that maintenance personnel record all faults and do not omit to record faults that are then rectified as part of the maintenance process. Such masking of faults would invalidate the machine history and hinder the review process.

*NOTE There is a need for managers to allocate time for routine inspection and maintenance (see **7.7.1**).*

7.5 Machine history files

Each loader crane should have its own machine history file, in either paper or electronic format, in which all records of maintenance activities are kept by the loader crane owner. These should include the following (as applicable):

- EC Declarations of Conformity, including any supplied with attachments (interchangeable equipment) and with replacement parts, e.g. wire ropes;
- special maintenance procedures;

- installation and commissioning inspection reports, including results of stability tests and overload tests, dynamic tests, sink rate tests and RCI/RCL calibration checks and functional tests;
- copies of final axle, stability and subframe drawings;
- any electrical installation drawings;
- in-service inspection reports;
- service reports and worksheets;
- breakdown reports and worksheets;
- daily and weekly inspection reports;
- thorough examination reports;
- overload test reports;
- records of supplementary tests;
- records of component replacement;
- records of major overhaul;
- attachment maintenance reports;
- records of defect rectification;
- data logger records;
- records of modifications and upgrades;
- safety alerts from manufacturers;
- records of extraordinary events;
- records of unusual applications (e.g. lamp post extraction).

7.6 Management review of maintenance records and procedures

For the safe and efficient operation of a loader crane fleet, a regular management review of loader crane maintenance records and procedures should be carried out by the managers responsible for the maintenance operation to enable them to be confident that a robust maintenance system is in place that can be relied upon rapidly to highlight any shortcomings and the need for corrective action. The review should include:

- checks that faults are being corrected and closed out appropriately and that the maintenance schedule is being completed to plan;
- checks to determine if the regime and frequencies are appropriate and to analyse trends.

The reviews should be carried out initially at least monthly. Once a suitable level of confidence in the systems has been established the review frequency may be reduced in the light of experience.

7.7 Site issues for maintenance

7.7.1 Maintenance downtime

PUWER 1998 [3] Regulation 5 requires employers to ensure that cranes are maintained in an efficient state, in efficient working order and in good repair.

As the main purpose of a loader crane is to carry out lifting operations, operations managers can be, understandably, reluctant to stop the crane while maintenance is carried out.

WARNING. It is essential that maintenance downtime is scheduled into the work programme, so that maintenance is not pushed to the back of the queue and does not end up being carried out hurriedly in unsafe conditions such as poor light.

Loader crane owners should make clear to those hiring their cranes that adequate maintenance downtime has to be built into the work programme. Hirers should be informed at the planning stage of the frequency and length of time required for maintenance operations.

Loader crane hirers should be informed that when maintenance of a loader crane is taking place the maintenance team have full control of the loader crane.

7.7.2 Communication

Those planning and carrying out maintenance on loader cranes on site should ensure that they have effective lines of communication with the site staff for both routine maintenance and attending to breakdowns. Maintenance personnel should always report their arrival on site, agree the programme of work to be carried out and report back once the tasks have been completed. This can avoid much frustration and misunderstanding on both sides.

7.8 Spare parts

Maintenance operations on loader cranes can only be fully effective if the correct spare parts are available at the correct location in a timely manner. A robust spare parts management system should be put in place to avoid any unnecessary direct and indirect costs and any adverse affects on the safety of the crane.

Where spare parts are not obtained from the crane manufacturer, parts should be obtained that meet the original manufacturer's specification. Where necessary, a full engineering assessment of the part(s) should be carried out to ensure that this is the case.

7.9 Use of special materials in loader crane construction

Modern loader cranes make extensive use of high tensile steels. When repairs are carried out to any parts of the crane structure, the correct procedure laid down by the manufacturer should be strictly followed to avoid changing the properties of the material.

8 Thorough examination of loader cranes

8.1 General

8.1.1 Thorough examination of a loader crane is required by LOLER 1998 [2] Regulation 9 in the following circumstances (see BS 7121-2-1:2012, **8.3.1**):

- before being put into use for the first time, unless the crane is new and the owner has an EC Declaration of Conformity dated not more than 12 months prior to the crane being used for the first time, LOLER Regulation 9(1);
- where safety depends on the installation conditions:
  - after installation and before being put into service for the first time, LOLER Regulation 9(2)(a);
  - after assembly and before being put into service at a new site or in a new location, LOLER Regulation 9(2)(b);

- periodically whilst in service, at maximum intervals of 6 months for cranes that lift people and 12 months for cranes that lift goods only, LOLER Regulation 9(3)(a)(i) and (ii);
- after exceptional circumstances have occurred, LOLER Regulation 9(3)(a)(iv).

WARNING. A thorough examination does not include assessment of roadworthiness as required by the Road Traffic Act 1991 [6] and regulations made under it.

8.1.2 The competent person should normally work to a defined scope of thorough examination (see **8.5**). The examination scheme approach (see BS 7121-2-1:2012, **8.9**) should only be used for loader cranes that are permanently installed.

8.2 Selection of the inspection body and competent person to undertake thorough examination

The crane owner should select the inspection body to undertake thorough examination, giving consideration to the experience, knowledge, competency and capacity of the provider. It is recommended that a long term relationship is built up with the provider rather than having too frequent changes in provider.

It is essential that the provider and competent person undertaking the thorough examination of a crane are sufficiently independent to be able to make decisions without fear or favour. Thorough examinations of loader cranes are often undertaken by maintenance providers. It is strongly recommended that the competent person undertaking through examination does not examine a crane on which he/she has recently carried out maintenance.

Where a user organization carries out maintenance of its own loader cranes, it is recommended that thorough examination is carried out by a third party external provider who is suitably independent.

In the case where a third party external provider is used for both maintenance and thorough examination, it is recommended that the employer of the competent person has an audit trail in place to demonstrate that the thorough examinations are being carried out with impartiality and integrity. This should include periodic auditing of the process by a senior engineer or manager of the company employing the competent person.

Where maintenance and thorough examination are to be undertaken by a single person, whether on a user's premises or elsewhere, the crane owner should ensure that the thorough examination is undertaken first before any maintenance work is undertaken. In such cases, any defects found at the time of the thorough examination should be declared on the report of thorough examination even if they were immediately rectified.

8.3 Scope of thorough examination before the crane is put into use for the first time

The competent person who undertakes the thorough examination should decide the scope of the examination. The extent of the thorough examination should reflect the likelihood of failure and the actual risk which could arise from any such failure. It should also take into account when the crane was made and the likely deterioration since manufacture, which could increase risks in use. Records of tests and inspections carried out by the manufacturer should also be taken into account.

8.4 Scope of thorough examination following installation

For loader cranes for which thorough examination after installation is required (see **8.1.1**), the competent person who undertakes the thorough examination should decide the scope of the examination. LOLER 1998 [2] Regulation 9(2)(a) and (b) requires that this establishes that the crane has been installed correctly and is safe to use.

As a minimum, the examination should ensure the crane has been installed, checked and tested in accordance with the manufacturer's instructions.

The scope of the thorough examination should be proportional to the complexity of the installation and the reports of previous thorough examinations, where applicable.

8.5 Scope of periodic thorough examination

8.5.1 General

The competent person carrying out a periodic thorough examination should work to a defined scope of thorough examination that has been drawn up specifically for the loader crane they are required to examine (see BS 7121-2-1:2012, **8.6**).

The defined scope of thorough examination should be drawn up in advance of the examination by a competent person and should identify those parts of the crane that should be thoroughly examined, together with required supplementary reports and tests and the extent to which they should be witnessed, and details of any required non-destructive testing of the crane structure and mechanisms.

The competent person carrying out the thorough examination may add to the defined scope but is not permitted to reduce it.

It is essential that the defined scope of thorough examination includes all components that may be used with the crane in different configurations, e.g. fly jibs and manual extensions, together with any dedicated ancillary equipment. Particular attention should be paid to wire ropes, see Clause **11**. Components that are regularly used with the crane should be included in every thorough examination of the crane. Other components should be thoroughly examined prior to use. Precautions, for example quarantining, should be taken to ensure that such components are not used unless there is a current through examination report for the component.

The competent person who prepared the defined scope of thorough examination should periodically review it to take account of changes in usage of equipment, findings of previous thorough examinations, supporting supplementary reports and tests, together with any information from maintenance activities, manufacturers or other sources. A copy of the defined scope of thorough examination should be kept in the machine history file.

The defined scope of thorough examination should, as a minimum, include the components listed in **8.5.2**. These components should be assessed against the criteria listed in **8.5.3**, taking into account the path of the load through the crane's structure and mechanisms. It is essential that the scope is risk based and takes into account the consequences of failure of the crane.

8.5.2 Components to be included

The following components should be included in the defined scope of thorough examination for a loader crane (as applicable).

NOTE 1 This list is not exhaustive.

a) General:

- loader crane structure;
- mounting of the loader crane to the lorry loader vehicle chassis, or the fixed base;
- subframe attached to the lorry loader vehicle chassis;
- bolt and fastenings used to attach the loader crane to the subframe and the subframe to the vehicle chassis;
- CE mark, manufacturer's information plate and load chart;
- lorry loader vehicle chassis, wheels, tyres, drive system, brakes, steering and suspension (where they can affect the safety of the lifting operations);
- access ladders, platforms, walkways, hand holds/hand rails and guard rails;
- operator's seat and restraint;
- slew column structure, including fasteners and slew ring;
- slewing mechanism;

  NOTE 2 Examination of the slewing mechanism should include its full range of movement.

  NOTE 3 Booms should be at maximum radius during the examination.
- hydraulic cylinders;
- pipe connections between the pump and the loader crane, the loader crane and the oil tank, and the oil tank and the pump;
- pipe-work and hoses on the loader crane;
- fluid in the hydraulic tank;
- hydraulic filters;
- control valves;
- power supply cables and cable reeling;
- controls, indicators, seating and windows;
- connections in the control system;
- control levers;
- rated capacity load plates;
- pivoting points on the loader crane;
- hoist winches, wire rope, rope termination and hook;
- hydraulic rotator;
- control cabinets and wiring;
- collective fall protection equipment, e.g. platform guard rail;
- anchor points for personal fall protection equipment;

- limiting and indicating devices including:
  - rated capacity system;
  - anemometer;
  - devices provided to ensure stability (stabilizer interlocks, tilt monitors, etc.)
  - anti-crush platform protection system;
  - slew limiting devices, including over-cab de-rating system.

b) Wire rope hoist:
- pulleys, sheaves and drums;
- idler pulleys/sheaves;
- guards;
- hoist rope and rope anchors;
- pressure roller and rope guide assembly;
- hoist limit switches;
- residual amount of rope remaining on the hoist drum when the crane hook is lowered to the ground with the boom in position at maximum elevation;
- over hoist limiting system;
- hoist rope line load or hoist torque limiter.

c) Fly jib or third boom:
- electrical and hydraulic connections;
- mechanical connections.

d) Control systems:
- legs not stowed warning (visual and/or audible);
- over height warning (visual and/or audible);
- notice displaying the travelling height of the lorry loader;
- system for preventing the boom striking a person at the raised platform control station;
- slew restrictor system;
- manual boom de-rate switch;
- leg deployment monitoring systems;
- stabilizer position monitoring devices;
- chassis tilt detection system.

e) Loader crane:
- stabilizer cam locks and automatic latches;
- stabilizer beams;
- swing up stabilizers locking device;
- stabilizer legs;
- stabilizer foot pads;
- supplementary load spreader mats;
- telescopic boom extensions.

f) Lorry loader chasis:
   - parking brake interlock;
   - power on demand facility;
   - air suspension control.

g) Attachment:
   - secondary pressure relief valves for attachment operation;
   - lifting hooks if fitted to the attachment.

8.5.3 Assessment criteria

The following assessment criteria should be included in the defined scope of thorough examination for a loader crane:

NOTE This list is not exhaustive.

- accuracy of limiting and indicating devices – within manufacturer's tolerances;
- adjustment – as specified by manufacturer;
- alignment – within manufacturer's tolerance;
- backlash – within manufacturer's tolerance;
- bearing play – within manufacturer's tolerance;
- brake performance – within manufacturer's tolerance;
- corrosion – affecting strength or functionality;
- cracks – affecting strength or functionality;
- cylinder creep – within manufacturer's tolerance;
- damage – affecting strength or functionality;
- distortion – affecting strength or functionality;
- fluid levels – within manufacturer's limits;
- functionality – as intended by manufacturer;
- guards – presence and condition;
- leaks – affecting strength, functionality and slips;
- lubrication – adequacy;
- markings – presence, accuracy and condition;
- mode of operation – as intended by manufacturer;
- obstructions – impeding safe access;
- rope fit – as specified by manufacturer;
- rope reeving – as specified by manufacturer;
- rope condition (see Clause **11**);
- rope specification – as specified by manufacturer;
- security – attachment of components and sub-structures, fasteners, welds, etc.;
- seizure – full or partial seizure of rotating components;
- tidiness – general housekeeping;
- wear – affecting strength or functionality.

8.5.4 Scope of periodic thorough examination for cranes that remain in service past their design life

If a loader crane is to be used past the original design life (see **7.2.3**) then the defined scope of thorough examination should be reviewed and amended by the competent person, taking into account the crane service, maintenance and thorough examination history and the results of the assessment of additional life expectancy (see **7.2.3**).

8.6 Periodic thorough examination interval

The statutory maximum intervals of 6 months and 12 months may be reduced to take into account environmental factors or the general age and condition of the crane, etc. The decision to reduce the interval between thorough examinations may be made by the competent person, the loader crane owner or the loader crane user.

Reasons for reduction of the interval between thorough examinations include the following:

- if the loader crane might be used for lifting of persons in exceptional circumstances, including rescue, even if it is not initially planned;
- to take into account the intensity of use of the crane and the environment in which it is used;
- if the competent person has concerns about the effectiveness of the maintenance regime.

8.7 Thorough examination after exceptional circumstances

LOLER 1998 [2] requires that if the crane is subjected to exceptional circumstances it has to be removed from service and subjected to a thorough examination to determine whether it is safe to be returned to service.

Exceptional circumstances include an unintended movement, overload, boom strike, collision, striking a bridge, sudden loss of load, use for particularly arduous duties, failure of a structural component or being subjected to weather in excess of design parameters.

The scope of the thorough examination should be proportional to the nature of the exceptional circumstances and the extent of any repairs, and should take into account the reports of previous thorough examinations, where applicable.

8.8 Preparation for thorough examination

Prior to thorough examination the loader crane should be cleaned by an appropriate means, e.g. pressure washed, to remove all spoil/dirt that would otherwise conceal the structure or mechanisms and prevent an effective examination.

If the local lighting is not adequate for examination purposes it should be supplemented by portable lighting.

The identification and rated capacity marked on the crane should be checked against the records, for example the test certificate, declaration of conformity, the manufacturer's instructions for use and the report of the last thorough examination.

The competent person carrying out the thorough examination should determine if there is any history of defects or malfunctions, and whether any repairs, alterations or additions have been made. The last report of thorough examination and in-service inspection reports should be consulted.

The crane should be made safe by isolating and locking-off the power supply when necessary and reinstating it as appropriate.

Where it is not possible to ascertain the condition of hidden mechanism parts, for example ropes, chains, sheaves, terminations or hydraulic cylinders, dismantling prior to thorough examination should carried out as required by the competent person.

Additional means of safe access should also be provided as required by the competent person, e.g. scaffolding, working platforms or mobile elevating work platforms.

NOTE Attention is drawn to the Work at Height Regulations 2005 (as amended) [7].

8.9 Rated capacity indicator/rated capacity limiter (RCI/RCL) calibration check and functional test

8.9.1 General

The periodic thorough examination of a loader crane (see **8.5**) should include a calibration check and functional test of the rated capacity indicator/rated capacity limiter (RCI/RCL) in accordance with BS 7121-2-1:2012, **10.15**.

When performing a calibration check and a functional test on the RCI/RCL of a crane with a hydraulic extension, any manual extensions should either be removed or their mass included in the load used for calibration or functional test.

The mass of the load used for calibration or functional testing should include the mass of any slings or chains.

8.9.2 Carrying out a calibration check

With the outer boom horizontal, the inner boom should be raised at the angle given on the rated capacity plate attached to the boom.

The radius should be measured from the centre line of rotation of the column to the centre of the load hook.

With the boom system retracted, a load should be lifted which is equivalent to 110% of the rated capacity for maximum hydraulic extension.

Keeping the load as close to the ground as possible, the radius should be increased by extending the boom system until the rated capacity indicator gives the approach to rated capacity warning.

At this point the radius should be measured and the load on the crane should be between 90% and 97.5% of the rated capacity for that radius unless a different value is specified in the manufacturer's instructions for use.

The radius should then be further increased until the rated capacity indicator gives an overload warning. It should not be possible to increase the radius beyond this point.

The radius should be measured again and the load on the crane should be between 102.5% and 110% of the rated capacity for that radius unless a different value is specified in the manufacturer's instructions for use.

9 Overload testing and dynamic testing of loader cranes, and measurement of sink rate

9.1 Overload test

9.1.1 General

Overload testing of loader cranes should be carried out to supplement thorough examination after first installation and after each re-installation. Loader cranes should also be overload tested after major repairs or modifications.

The competent person preparing the defined scope of thorough examination may also specify in-service overload testing to supplement thorough examination at intervals throughout the life of the crane.

Lorry loaders rely not only on the structural integrity of the mountings, but also on the vehicle chassis and suspension. Consequently, current industry practice is to carry out overload testing after the lorry loader has been in service for 4 years, 8 years, 10 years and 12 years, and annually thereafter.

9.1.2 Before testing

The competent person should seek advice from the crane manufacturer (or other suitable design authority) before deciding on the nature of the test and the method of carrying it out.

A visual examination of the crane and the test area should be carried out prior to commencing the test.

Before application of a load, a thorough examination of the crane should be carried out. A function test should also be carried out without a load to check that all safety devices are functioning correctly.

Before overload testing of a lorry loader, the loader crane should be loaded with a load equivalent to the rated capacity at maximum hydraulic extension and the vehicle checked for stability.

All attachments (e.g. buckets, grabs, rotators), with the exception of the hook, should be removed before testing.

Hydraulic fluid should be at normal operating temperature before testing commences.

In the case of a lorry loader, the stabilizer legs should be fully extended and the vehicle tyres inflated to the manufacturer's recommended pressure. If the loader crane is mounted on a vehicle with active air suspension, the air should be dumped and the suspension locked off in the fully deflated position before the stabilizer legs are deployed. The stabilizer legs should be extended sufficiently to be in firm contact with the ground, so that they provide adequate support for the loader crane, but should not be extended so far that they take the load from the wheels and reduce the efficiency of the parking brake.

The relief valve system, rated capacity indicator and rated capacity limiter, should be overridden or disconnected before the test.

9.1.3 Testing

9.1.3.1 General

The loader crane should be tested in all configurations and at all rated capacities for which it is designed to be used, including reduced rated capacity areas, different stabilizer positions, and with different manual sections, or with fly jibs or third booms.

In the case of a lorry loader, the overload test should be carried out with the vehicle unloaded and without the operator in the cab.

Fly jibs should be tested in the position shown in the manufacturer's load diagram.

For loader cranes equipped with manual extensions and/or a fly jib or third boom, the jib and/or manual sections should be removed and the basic loader crane tested first. The jib and/or manual sections should then be remounted and the crane tested with these.

9.1.3.2 Test procedure

The test load for the overload test should equate to 1.25 × the rated capacity of the crane for the radius at which the test load is to be applied. The loads imposed by all lifting accessories (e.g. shackles and chains) should be counted as part of the test load.

The initial raising of the load should be at the shortest possible radius and with the boom direction facing a stable part of the slewing arc. Once a satisfactory test lift has been made, the load should be carefully extended outwards to its intended radius.

The load should be kept as close to the ground as possible, allowing for boom deflection and vehicle stability, and slowly slewed once throughout the full in-service slewing arc of the crane.

Sudden load movements, including load braking, should be avoided to prevent shock loading.

The process should be repeated at other radii and in other configurations, including reduced capacity areas, as deemed appropriate by the competent person for the specification of the loader crane and its installation.

The test should be considered successful if no connection has been loosened or damaged and if there are no cracks, permanent deformation, paint flaking or damage which affect the function or safety of the loader crane and its installation.

NOTE The overload test for maximum hydraulic radius is not required if a stability test is made at the same radius, although overload testing should still be conducted at other radii and in other configurations as deemed appropriate by the competent person.

9.2 Dynamic test

Following the overload test, the test load should be reduced to the equivalent of 1.1 × the rated capacity of the crane at maximum hydraulic outreach, and a dynamic test should be conducted.

The object of the dynamic test is to subject the hydraulic system and structural members to dynamic conditions and fluctuating loads, in order to check each powered function through its full range of travel and operating speeds, and to check the operation of the load decelerating valves.

Dynamic tests should be performed separately for each loader crane motion, and with simultaneous crane motions using positions and configurations that will impose the maximum loading or maximum stresses in the crane components (i.e. least favourable conditions).

Testing should be carried out at speeds appropriate to those for normal crane operation and should include repeated starting and stopping of each motion throughout the range of the motion. However, aggressive shock loading should be avoided.

The crane should be tested first in its basic configuration. Any manual boom sections or fly jibs should be removed whilst the initial test is conducted and then refitted and the crane tested again.

Hydraulic oil should be at normal working temperature and the RCI and RCL should remain disabled from the overload test.

All crane positions attainable in service should be reached during the course of the tests.

The test should be considered successful if all components have been found to perform their functions correctly in accordance with the design specification and if an examination after the test reveals no damage to the mechanisms or structural components. The hydraulic oil should also be at a satisfactory temperature at the end of the continuous test period.

At the conclusion of the dynamic test, the relief valve system, rated capacity indicator and rated capacity limiter should be fully reinstated and resealed as required. Sealing pliers used for this purpose should be traceable to the individual by means of a unique mark or number.

9.3 Measurement of sink rate

Leakage of fluid from, or within, hydraulic components causes the crane to sink towards the ground.

After the overload test, the sink rate should be measured.

The test should be carried out using a load equivalent to the maximum rated capacity of the crane and at maximum hydraulic outreach. The distance between the boom tip and the ground should be measured at the start of the test and again after the load has been suspended for 10 min.

The sink rate should not exceed the following, as applicable:

- 0.5% of outreach per minute for loader cranes with a maximum hydraulic outreach of up to 12 m;
- 0.2% of outreach per minute for loader cranes with a maximum hydraulic outreach of over 12 m;
- 2% of outreach per minute for timber handling cranes.

10 Non-destructive testing of loader cranes to supplement thorough examination

Non-destructive testing (NDT) of loader cranes is a valuable aid to the identification of cracks and other defects in crane structures damaged by fatigue, corrosion or overloading.

The competent person responsible for preparing the defined scope of thorough examination for the crane (see **8.5**) should determine the extent, frequency and nature of any non-destructive testing required to supplement thorough examination. For cranes less than 8 years old the competent person may deem that NDT is not necessary. However, it is recommended that NDT should be undertaken on all cranes older than 8 years.

The non-destructive testing should be applied to structural members, mechanisms and components that are critical to the structural integrity of the crane. When determining the non-destructive testing required, the competent person should take the following into account:

- the standard to which the crane was designed;
- the original design life given by the crane manufacturer;

- the number of lifts and magnitude of the lifts completed by the crane;
- the environment in which the crane has been used;
- the crane's maintenance history;
- repairs and alterations that have been carried out on the crane;
- any damage to the crane structure following collision with bridges, fixed structures, vehicles or other cranes;
- the magnitude and frequency of overloads and shock loads on the crane;
- the results of previous non-destructive testing of the crane;
- any safety alerts issued by the crane manufacturer, trade associations and/or trade bodies, professional bodies and/or enforcing authorities;
- the results of any fatigue assessment undertaken by the manufacturer or by other persons, including the following information where provided:
    - identification of all areas of the crane that might be subjected to frequent cyclic loading;
    - the level and frequency of stress that the crane might be subjected to during normal and abnormal operation;
    - the materials of construction and the areas of the crane structure that might act as stress raisers, such as welds and section changes.

The following areas should be subjected to non-destructive testing:

NOTE 1 These areas are illustrated in Figure 1.

a) areas between cast and fabricated column components;

b) changes of section on the column;

c) fabrications;

d) links and linkages;

e) complex fabrications;

f) helper frame cleat plates;

g) holding down blocks;

h) hook attachment;

i) helper frame waisting;

j) stabilizer extension beams;

k) cast components;

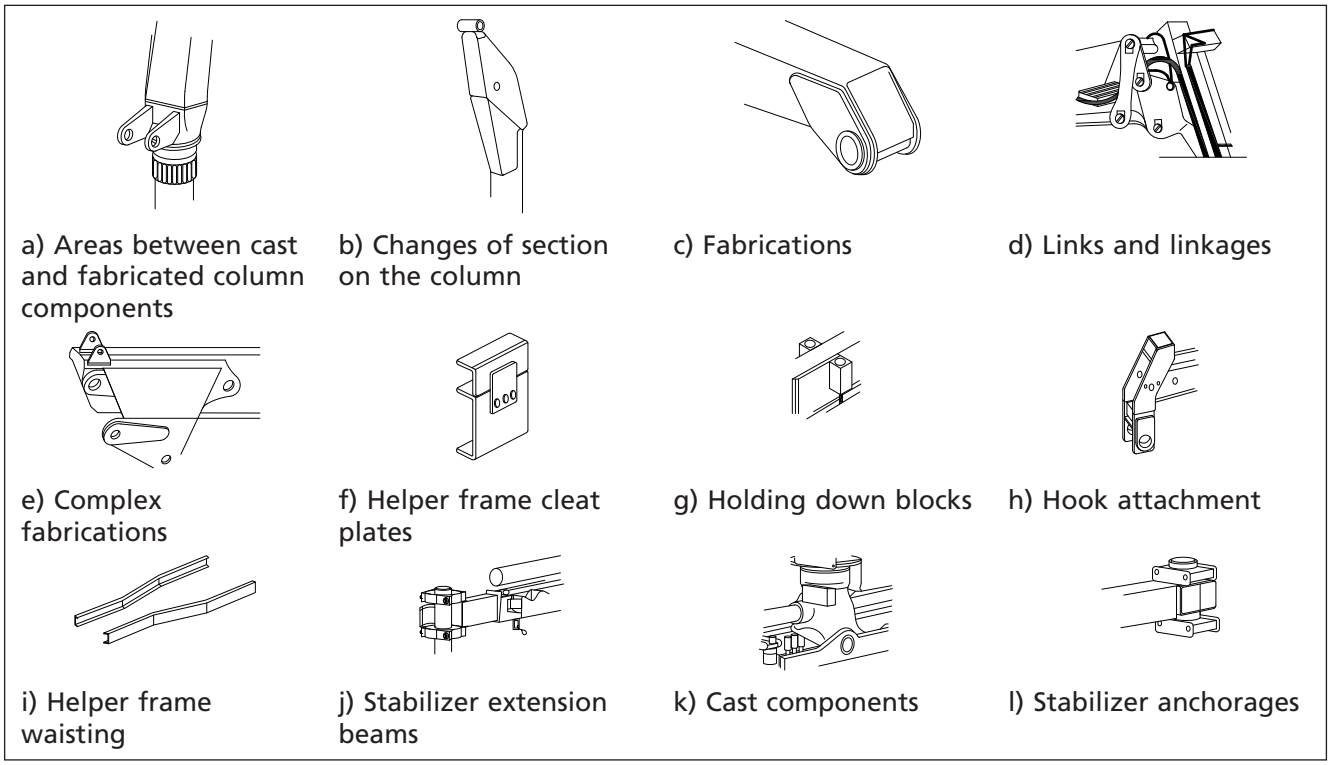
l) stabilizer anchorages.

After NDT any paint removed during testing should be made good to prevent corrosion.

NDT reports or test certificates should be appended to the thorough examination report.

NOTE 2 When NDT is being considered, the crane owner might want to compare the cost of undertaking the testing against the cost of a replacement part. Often the cost of replacing a part with a new one can be less than the cost of NDT.

Figure 1 **Areas to be subjected to NDT**



11 Assessment of wire rope condition and discard criteria

When carrying out examination of wire ropes as part of the thorough examination of a loader crane, the competent person should examine the rope in accordance with BS ISO 4309:2010, Clause **5** and Clause **6**. See BS 7121-2-1:2012, Clause **14**.

Annex A (informative) Example of a pre-use checklist for a loader crane and for a lorry loader

The following is an example of a checklist for pre-use checking of a loader crane and a lorry loader.

NOTE 1 For a loader crane which is not part of a lorry loader, the items in the checklist relating to the vehicle should be omitted.

NOTE 2 These checks are in addition to any checks needed in accordance with the manufacturer's instructions. This list is not exhaustive.

a) In the vehicle cab:
   1) check operation of the power take-off cab switch;
   2) check handbrake interlock (if fitted);
   3) check height warning signs are present and correctly set;
   4) check for current report of thorough examination;
   5) check for loader crane manufacturer's manual.

b) Hydraulic fluid:
   1) check hydraulic fluid level;
   2) check colour/condition of the hydraulic fluid (visual check);
   3) check for hydraulic fluid leaks.

c) Attachment (if fitted):
   1) check operation of attachment;
   2) check condition of attachment (e.g. brick grab rubbers, clamshell wear blades);
   3) check means for stowing of attachment on vehicle;
   4) check attachment for hydraulic fluid leaks.

d) Stabilizers:
   1) check stabilizer beam cam-locks;
   2) check stabilizer beam secondary locks;
   3) check swing-up stabilizer pins/locks;
   4) check stabilizer hoses/pipework;

e) Loader crane:
   1) check loader crane operation;
   2) check operation of control levers and remote controls;
   3) check all control decals, rated capacity plates and safe-use decals are present and legible;
   4) check operation of rated capacity indicator/limiter, as applicable;
   5) check operation of emergency stop switches;
   6) check operation of height warning/boom not stowed device;
   7) check any additional safety systems;
   8) check condition of hook and safety catch;
   9) check the function of the loader crane stowing brackets, pins and locks;
   10) check attachment of loader crane to vehicle.

f) Lifting accessories:

1) check correct lifting accessories are present;

2) check condition of lifting accessories;

3) check report(s) of thorough examination are current for all accessories.

Annex B (informative)

In-service inspection – Example of additional checks to be carried out in addition to pre-use checks, at intervals of 1 week to 1 month

The following is an example of a checklist of additional checks to be carried out at in-service inspection of a loader crane or a lorry loader at intervals of between 1 week and 1 month. These are in addition to the checks listed in Annex A.

NOTE 1 For a loader crane which is not part of a lorry loader, the items in the checklist relating to the vehicle should be omitted.

NOTE 2 These checks are in addition to any checks needed in accordance with the manufacturer's instructions. This list is not exhaustive.

a) Hydraulic system:

1) check filters and bowls for cleanliness including check level indicator for high pressure filter;

2) check integrity of suction, pressure and return hose fittings;

3) check integrity of hydraulic pump mounting bolts;

4) record the hour-meter reading or run time/load time reading (if fitted).

b) Attachment (if fitted):

1) check all capacity plates and safe use decals are present and legible;

2) check condition of additional lifting hooks and safety catches;

3) lubricate attachment in accordance with manufacturer's instructions.

c) Loader crane:

1) lubricate loader crane in accordance with manufacturer's instructions;

2) visually check crane structure for signs of cracks, deformation and paint flaking;

3) check security of extension wear pads and leg beam rollers.

Annex C (informative)

In-service inspection – Example of checklist for in-service inspections at intervals of 3 months to 6 months

The following is an example of checklist for in-service inspection of a loader crane or a lorry loader at intervals of between 3 months and 6 months.

NOTE 1 For a loader crane which is not part of a lorry loader, the items in the checklist relating to the vehicle should be omitted.

NOTE 2 These checks are in addition to any checks needed in accordance with the manufacturer's instructions. This list is not exhaustive.

a) Hydraulic system and drives:
   1) check oil level and condition of oil;
   2) check condition of filters/bowls;
   3) check for change of filter(s);
   4) check for contamination of hydraulic system;
   5) check operation of power take-off (PTO);
   6) check PTO-pump retaining bolts;
   7) check handbrake interlock;
   8) check hydraulic pump for leaks;
   9) check tamper proof seals;
   10) check working pressure of loader crane;
   11) check pressure on first boom cylinder;
   12) check pressure on second boom cylinder;
   13) check pressure on slew system;
   14) check condition of hydraulic pipes;
   15) check condition of hydraulic hoses;
   16) check engine r.p.m. setting;
   17) check for leaks on stabilizer cylinders;
   18) check for leaks on slew cylinders;
   19) check for leaks on first boom cylinder;
   20) check for leaks on second boom cylinder;
   21) check for leaks on extension cylinder(s);
   22) check for leaks on hydraulic rotator;
   23) check for leaks on grab attachment;
   24) check for leaks on hoist;
   25) check for leaks on control valve;
   26) check for leaks on swivel connectors;
   27) check for leaks on all connections.

b) Mountings, subframe and loader crane structure:
   1) check condition of subframe;
   2) check holding down bolts;
   3) check subframe bolts;

4) check for cracks on base;
5) check for cracks on pendulum beam;
6) check for cracks on column;
7) check for cracks on first boom;
8) check for cracks on second boom;
9) check for cracks on extension(s);
10) check for cracks on stabilizers;
11) check for cracks on grab attachment.

c) Additional checks:
1) check condition and function of stabilizer beam cam-locks;
2) check condition and function of stabilizer beam secondary locks;
3) check condition and function of stabilizer leg swing-up locks;
4) check operation of stabilizers;
5) check operation of loader crane functions;
6) check greasing points;
7) check hook condition;
8) check hook safety catch condition;
9) check condition of hose sleeves;
10) check rated capacity charts are present and legible;
11) check safe use decals are present and legible;
12) check control lever decals are present and legible;
13) check function of boom height warning signs in cab;
14) check condition and function of control levers and linkages;
15) check remote control handset condition;
16) check remote control handset function;
17) check auto-lube function and grease level;
18) check condition of auto-lube pipe work;
19) check condition and function of roll-loader anchorages;
20) check condition and function of roll-loader drives;
21) check condition of roll-loader power pack;
22) check condition of wire rope;
23) check operation of hoist;
24) check operation of load-moment diverter;
25) check operation of boom height warning system;
26) check operation of stabilizers stowed/locked warning system;
27) check operation of diverter valve;
28) check operation of overload system;
29) check operation of RCL/RCI;
30) check operation of stabilizer monitoring/tilt system;
31) check operation of emergency stop(s);

32) carry out calibration check;
33) check operation of slew de-rate system;
34) check operation of platform protection system;
35) check function of other safety systems;
36) check for wear on pendulum beam pivot;
37) check for wear on pins and bushes;
38) check for wear on extension cylinder and guide rail;
39) check for wear on extension wear pads and retaining screws;
40) check for wear on column bearings;
41) check condition and conformity of access/egress to raised control stations.

Annex D (informative) Example of an in-service inspection checklist for a loader crane attachment

The following is an example of a checklist for in-service inspection of a loader crane attachment:

NOTE These checks are in addition to any checks needed in accordance with the manufacturer's instructions. This list is not exhaustive.

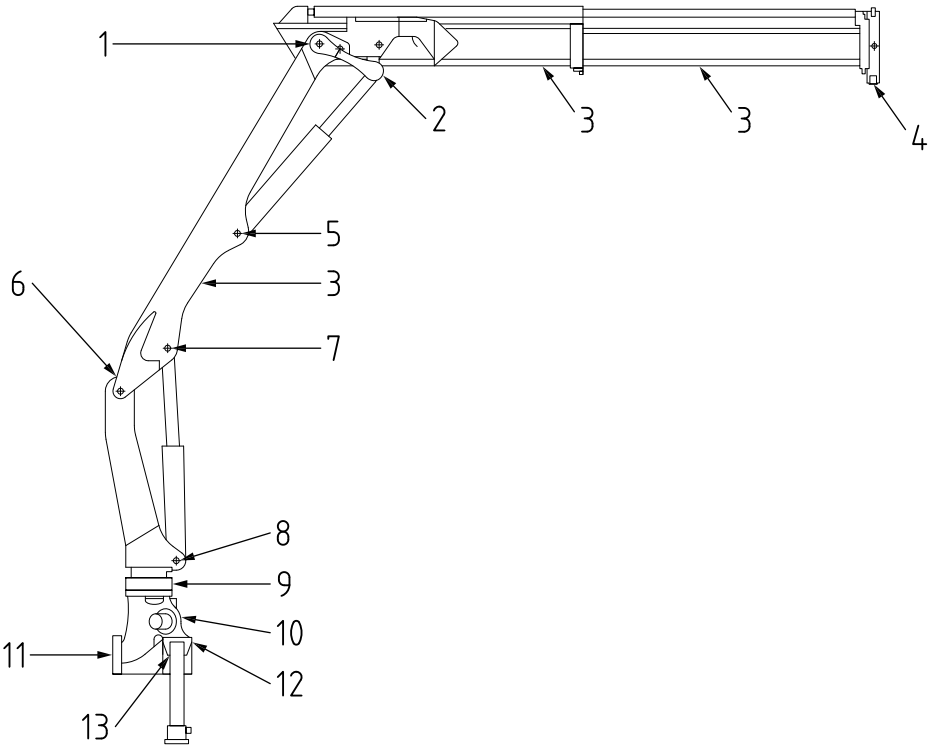
a) check for structural cracks/distortion;
b) check operation of attachment;
c) check operation of rotator;
d) check condition and security of "A" link and pin(s);
e) check condition and security of rotator bolts;
f) check condition of hydraulic cylinders;
g) check condition of pipework;
h) check condition of hydraulic fittings;
i) check condition of quick-release couplings;
j) check condition of brick grab rubbers;
k) check condition of brick grab rails;
l) check condition and security of hooks fitted to attachment;
m) check condition and function of hook safety catches;
n) check condition of clamshell bucket blades;
o) check condition of augur winding mechanism;
p) check condition of augur stowing device;
q) check condition of lubrication points;
r) check that lubrication has been carried out in accordance with the manufacturer's instructions.
s) check safe-use decals are present and legible;
t) check that rated capacity plate(s) are present and legible.

Annex E (informative)

Stress concentration points in loader cranes

The areas that should be included in the in-service structural inspection of a crane are those likely to be subjected to high levels of stress. The most important points of stress concentration on a loader crane are illustrated in Figure E.1.

Figure E.1 **Stress concentration points on a loader crane**



Key

1. Connection between first boom and second boom
2. Connection between second boom cylinder and linkage/second boom
3. Closing welds on underside of booms
4. Hook/grab suspension points
5. Connection between first boom and second boom cylinder
6. Connection between first boom and column
7. Connection between lift ram and first boom/linkage
8. Connection between lift ram and column
9. Top of base around upper column bearing
10. Rear of base around slew rack guidance
11. Connection between crane base and pendulum beam
12. Connection between crane base and stabilizer assembly
13. Connection between stabilizers and stabilizer beams

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