

Code of Practice for

Safe use of cranes (mobile cranes, tower cranes and derrick cranes)

UDC 621.873:614.8

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Amd. No.	Date of issue	Comments
1148	1973	Indicated by a sideline in the margin

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Foreword

This Code of Practice, which is published under the authority of the Codes of Practice Committee for Mechanical Engineering deals with those types of crane most commonly employed in works of engineering construction; mobile cranes, tower cranes and derrick cranes. A further British Standard is to be prepared which will cover electric overhead travelling cranes, portal cranes, high pedestal cranes and other types.

Preparation of this Code was prompted by concern at the increasing number of accidents involving cranes which, quite apart from the costly damage sustained, often result in serious personal injury or death. With a growing number of cranes being employed in an ever wider variety of job applications and environmental conditions and with the introduction of novel designs of crane offering greater technical sophistication, increased lifting capacities and new extremes of operating range, the accident rate will continue to rise unless positive measures are urgently taken to counter this trend. The misuse of cranes through lack of knowledge and understanding, rather than by intent, is a major cause of accidents. The aims of this Code are therefore:

- 1) to describe the principal characteristics of the various forms of cranes of the types most commonly used in works of engineering construction;
- 2) to draw attention to some of the more common hazards and potential dangers which may be encountered in their use; and
- 3) to recommend general precautions to be taken and procedures to be followed to avoid accidents.

Recommendations are advisory in nature and are intended to supplement relevant Government regulations which should be observed.

The Code was prepared by a committee of representatives from different branches of the crane industry. Their combined experience and specialist knowledge in the fields of crane design, manufacture, application and safety ensured that the recommendations are well-founded and practical. It was recognized by the Committee that the safe use of a crane ultimately rests with the operating personnel and the Committee were unanimous in their view that there is an urgent need for the introduction of a national system for licensing crane drivers to operate only those types of cranes for which they have received training and have demonstrated their competence. However, management have the overall responsibility for safety and supervision and it is to management that this Code is primarily directed. It is hoped that the Code will be used by management both as a working guide and in the training of personnel and that appropriate information and recommendations will be incorporated in their company standing instructions for the safe use of cranes.

The Committee acknowledges with appreciation the great assistance given by many persons and organizations whose names do not appear in the Constitution. A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 80 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 General

1.1 Scope

This Code gives guidance for the safe application and operation of mobile cranes, tower cranes and derrick cranes. Subjects covered include general recommendations for testing, maintenance, erection and dismantling procedures and siting of cranes together with recommended requirements for drivers, slingers and signallers.

Reference is also made to relevant Government regulations and attention is drawn to statutory requirements for the testing and examination of cranes.

Section 1 contains guidance notes and general information pertaining to the safe use of cranes of the types covered in Sections 2, 3 and 4.

1.2 Definitions

For the purposes of this Code the following definitions apply. Where appropriate, definitions from existing British Standards have been used. Where more than one term is shown for a definition, that first listed is the preferred term. The second term, shown in brackets, is an alternative in common use.

“A”-frame.
see “Gantry”

anchorage
a means of securing a crane in position such as foundation bolts

anemometer
an instrument for measuring wind speed

angle indicator
see “Jib angle indicator”

automatic safe load indicator
a device fitted on a crane which normally provides an automatic warning of approach to the safe working load and gives further indication when this has been reached (see definition of “safe working load”). Under certain statutory regulations the automatic safe load indicator should be of a type approved by H.M. Chief Inspector of Factories. See also “Load/radius” indicator

auxiliary hoist rope
a secondary load-lifting rope from an auxiliary drum, usually for use in lifting lighter loads than the main hoist rope, for example, over the fly-jib (see Figure 15)

axle lock

a device which may be fitted on wheel-mounted mobile cranes to prevent relative movement between a sprung/pivoted road axle and the chassis frame of the crane mounting, in order to increase the stability of the crane during lifting operations

“Baby”
see “overhauling weight”

back stays (or guy legs)
the structural members of a derrick crane which extend backwards and down-wards from the top of the mast (or king post) to the outer end of the crane sleepers (or lying legs) (see Figure 27)

ballast (kentledge)
dead weight built-in or added to the structure of a crane to ensure adequate stability. On derrick cranes the ballast, also known as kentledge is applied centrally at the intersection between the sleepers and the back stays

blocked condition
see “Outriggers set”

blocking-up base
the effective spans of the supporting base when outriggers or other means are used to increase stability (see Figure 16)

bogies

1) *Rail-mounted cranes.* The multi-axle wheeled carriages on which certain rail-mounted cranes travel. Bogies can be with or without a power driven travelling motion (see Figure 21, Figure 28 and Figure 29).

2) *Truck-mounted crane.* Two or more close-coupled axles on a vehicle used as a mounting for a crane.

bolster
a safety structure fitted on the truck of a truck crane to prevent the crane jib bouncing or striking the truck driving cab during transportation (For travelling conditions, the jib should be fully supported by the crane suspension ropes and positioned with adequate clearance to ensure that it does not strike the bolster when in transit.) (See also “Jib rest”.)

bowsill (or stringer)
the horizontal structural member of a derrick crane which connects the sleepers at or near to the outer or stay ends, so forming with the sleepers and pivot structure a rigid triangle (see Figure 29)

bracing (or lacing)

the secondary structural elements of a jib which join together (or brace) the main chord members

cantilever jib

a jib supported at two places near to its lower end. Essentially the upper end of the structure is not externally supported (see Figure 14)

capacity chart (or plate)

a notice fitted on a crane specifying the lifting capacities of the crane at different load-radii and for different operational conditions

cat-head

that part of a tower crane structure above the tower, to which jib ties are attached (see Figure 18)

caterpillar tracks

see “Crawler tracks”

centre of rotation (or slewing centre)

the vertical axis about which the upperworks of a crane slews or rotates (see Figure 1)

climbing crane

a tower crane which is supported by the building or structure within which it stands, and which can be raised as the number of storeys increases (see Figure 20)

climbing frames

frames which carry the tower of a climbing crane and which transfer the loadings from the crane on to the structure that supports it (see Figure 20)

climbing ladders

vertical structural frameworks by means of which some types of climbing crane are raised (see Figure 20)

condition of tipping

a crane is deemed to be in a condition of tipping when it is subjected to an overturning moment which cannot be increased by even a small amount without causing the crane to fall over

counterbalance

dead weight added to the structure of a tower crane to balance the weight of the jib (see Figure 21)

Counterbalance hanger bars

bars holding the counterbalance weights in position on the counter-jib of a tower crane

counter-jib

a secondary jib which carries the counterbalance (see Figure 21). Some types of tower crane have no counter-jib, the counterbalance being incorporated in the ballast which is situated at or near chassis level (see Figure 21)

counter-jib ties

ties which support the outer end of the counter-jib on a tower crane

counterweight

weights added to a crane in such a position as to provide a counterbalancing effect (see Figure 1 and Figure 21)

crane

a machine incorporating an elevated structural member or jib beneath which suspended loads can be controllably raised or lowered vertically and also moved horizontally either by slewing the crane, derricking the jib or by other means not solely involving a travelling motion of the crane

crane centres

the distance between the centre line of the mast of a derrick crane and the centre line of the pin connecting the back stay to the sleepers (see Figure 27 and Figure 28)

NOTE Depending on the design of the crane, this dimension may not be the same as the track centres.

crawler tracks (or caterpillar tracks)

self-laying tracks to assist travel over soft or unmade ground (see Figure 13 and Figure 24)

derrick crane

see Section 4

derricking (or luffing or jibbing)

angular movement of the crane jib in a vertical plane to change the hook radius (See also “Trolleying”.) (See Figure 1.)

derricking ties (or suspension or jib ties or pendants)

ties which support the outer end of the jib. On a derricking jib, the ties are usually fixed lengths of rope incorporated in the suspension system to reduce the length of the live derricking part of the suspension system. Also, sectional lengths of ties facilitate adjustment in suspension length when changing the length of the jib on mobile cranes (see Figure 15)

digging lock(s)

a ratchet safety mechanism fitted on some crawler cranes which can be selectively engaged to prevent movement of the tracks in one or other direction or both. Usually found on cranes derived from excavators; hence the term digging lock

fall-block

see “Hook block”

falls of rope

the total number of vertical parts of rope or lines from which the pulley hook block is suspended (See “Parts of rope”.)

fixed luff jib

a jib which can be adjusted to a fixed angle of inclination (see Figure 19.)

fixed tower

a tower which does not slew with the jib and load, the slewing ring being situated at or near the top of the tower (see Figure 18)

fly-jib (or jury jib)

a detachable auxiliary jib fitted at the end of the jib (see Figure 14)

fly-jib mast

a tall structural member located near the jib-head which carries the fly-jib suspension guys (see Figure 15)

folding jib

see “Gate hinge section”

free-on-wheels (or mobile condition)

the operational condition of a wheel-mounted crane when supported solely by its wheels and able to handle appropriate loads without requiring the use of outriggers. Note that free-on-wheels duties, if permitted, may be accompanied by restrictions imposed by the crane manufacturer in respect to travelling the crane with loads suspended from the hook, travelling speed, jib length, etc.

free-standing height

the maximum height at which a tower crane can operate without being held by ties or guys

gabbards

a structure of vertical towers and where necessary inter-ties on which a derrick crane is erected. They may be in fixed positions or mounted on travelling bogies (see Figure 29)

gantry (or “A”-frame)

an elevated structure in the basic crane which carries the jib suspension ropes (see Figure 15)

gate hinge section

a structural element inserted in a jib to permit folding of the jib to reduce the overall length when transporting a crane. (Certain designs of jib incorporate pinned folding hinges which are an integral part of the jib structure to achieve the same object.)

gauge

the dimension between the inner faces of the rail heads of the rail track

hammerhead (or swan-neck jib)

a jib incorporating a forward off-set or crank in the upper part of the structure to achieve, for example, an increased clearance between a suspended load and the jib structure

height of lift

the vertical distance between the ground or other datum level and the seat of the hook, when the hook is in the highest position

hoisting/lowering

the movement of the hook/load in the vertical direction (see Figure 1)

hook block (or fall block)

the pulley block attached to the crane hook which is suspended in the falls of the load hoisting rope

inner and outer tower

a structural arrangement whereby the jib of a tower crane is carried by a small slewing inner tower which is supported at the top of the larger fixed outer tower (see Figure 18)

intermediate suspension

additional suspension ropes attached at one or more intermediate positions along the length of a jib. The purpose of the intermediate suspension is to reduce the sagging deflection of long jibs and to dampen out vibrations (see Figure 15)

jib (or boom)

the main structure from which the load is suspended

jib angle indicator

a device fitted on a crane with derricking jib which shows the angle of inclination of the jib

jib foot

the end of the jib nearest to the crane

jib head (or point)

the end of the jib remote from the crane

jib length

the shortest distance between the centre of the jib pivot or foot pin and the centre of the jib head pulley pin

NOTE If jibs have a portion which extends to the rear of the jib pivoting point, that portion is ignored when stating the jib length.

jib rest

a structure fitted on the truck of a truck-mounted crane to provide support for the crane jib during transportation (The jib is usually positively attached to the jib rest which may incorporate springs or other means to protect the structure from shock loadings in transit.) (See also “Bolster”.)

jib safety stops

structural members, which bear on the jib when it is raised to maximum elevation to help prevent the jib kicking backwards over the cab. Also to protect the driver and minimize damage to the machine should the jib fall backwards over the top of the cab (see Figure 15)

jib safety ropes

see "Safety ropes"

jib ties

see "Derricking ties"

kentledge

see "Ballast"

kingpost

- 1) *Mobile crane*. The vertical pivot in the axis of rotation about which the crane upperworks slews (or rotates).
- 2) *Derrick cranes*. See "Mast".

lacing

see "Bracing"

level indicator

a device fitted on a crane which shows whether the crane is standing level or not

level luffing

an arrangement whereby the hook moves approximately horizontally when the jib is derricked (or luffed)

limit switch

an automatically-actuated device to stop a particular crane motion at its extremity(ies) or limit(s) of operation

load-radius indicator

a device fitted on a crane which shows the radius of the hook and the corresponding safe working load

lowerworks

the non-rotating lower part of a crane, including mounting, located below the slewing ring (see also "Upperworks")

low pivot jib

a jib in which the jib foot is pivotally attached directly to the revolving frame or turntable of a mobile crane

luffing

see "Derricking"

main chords

the principal longitudinal structural members of a jib. For example, a jib of rectangular cross section would have four main chords. The chords may be of angular, round tube, rectangular tube or other cross section

main hoist rope

the principal load lifting rope

margin of stability

when the crane is handling any safe working load at the appropriate radius, the margin of stability is the additional load, expressed as a percentage of the safe working load, which is required to bring the crane to a condition of tipping with the jib adjusted as necessary to maintain the same operating radius

mast

1) *Mobile cranes*: Suspension mast (or Forward A-frame or Forward gantry): A tall structural member located at or near the jib foot which carries the jib suspension ropes. The mast supplements the function of the gantry. (See Figure 15.) See also "Mast crane".

2) *Derrick cranes* (Mast or Kingpost): The vertical rotating structural member of a derrick crane to which is attached the machinery and jib foot mounting (see Figure 27).

mast crane

a mobile crane on which a jib is mounted near the top of a structural mast member which is erected to and maintained in a substantially vertical position by a suspension system. The crane is generally operated from the conventional crane cab (see Figure 14)

mobile condition

see "Free-on-wheels"

mobile crane

see Section 2

mono tower

an arrangement whereby the jib of a tower crane is carried by a single tower which may be either fixed or slewing (see Figure 18)

outreach

the horizontal distance from the centre line of the lifting hook to the nearest point of the machine other than the jib (see Figure 1)

outriggers

extensible structural members on the crane mounting to increase the effective base on which the crane stands (See "Blocking-up base".) (See Figure 16, Figure 22 and Figure 24.)

outriggers set (or blocked condition)

the operational condition of a wheel-mounted crane when supported on its outriggers to permit handling of appropriate loads (see Figure 16)

overhauling weight (or ponder weight, pear weight or "baby")

a weight securely fitted to the hoisting rope above the lifting hook, to cause the empty hook to lower under gravity

parts of rope

the total number of rope lines supporting a structure, e.g. the jib (See also “Falls of rope”).

pear weight

see “Overhauling weight”

pendants

see “Derricking ties”

ponder weight

see “Overhauling weight”

proving ring

a weighing device sometimes used in the testing of cranes. An accurately calibrated steel ring is suspended between the crane hook and the load. The measured diametral deformation of the ring is proportional to the weight of the load

pulley (or sheave)

a grooved wheel over which a rope passes. On cranes pulleys are usually shaft mounted and free to rotate under movement of the rope

radius

the horizontal distance between the point at which the centre of rotation of the crane meets the ground, and the vertical centreline through the hook (see Figure 1)

NOTE In the case of a non-slewing crane, the radius is the horizontal distance from the centre of the lifting hook to the centre line of the nearest axle or bogie measured at ground level.

rail centres

the dimension between the centres of the rail heads

rail clamps

crane fittings which can be engaged with the rail to prevent a rail-mounted crane being blown along the track under out-of-service conditions

rail stops

brackets bolted to rails, or other devices, to prevent rail-mounted cranes running off the end of the track

rail ties

ties used to retain rails at the correct distance apart and to withstand the imposed tensile and compressive forces

rear pivoted luffing jib

a luffing jib which is pivoted towards the rear of the tower on which it is supported (see Figure 19)

saddle (or trolley)

a wheel-mounted structure mounted on the jib of a crane and from which the hook is suspended. Movement of the saddle along the jib is controllable and provides the means of varying the hook radius (see Figure 19)

saddle jib

a jib which carries a saddle or trolley from which the hook is suspended (see Figure 19)

Safe working load (also rated load or rating)

the maximum load which can be safely handled by a crane **under specified conditions**

NOTE The safe working load may include the weight of the hook block and load/hook attachments such as slings, spreader bar, etc. The weight of these should be deducted from the listed safe working load to obtain the nett load.

safety hook

a crane hook provided with a safety latch across the throat opening of the hook to prevent the sling being accidentally dislodged

safety ropes (jib arrestors)

ropes fitted between the underside of the jib and a fixed part of the crane to counter whip-back of the jib, for example, if a load is suddenly released. Safety ropes may also be fitted between a fly-jib and jib (see Figure 15)

scotch derrick

see Section 4

service conditions

1) *In service*. With the crane handling loads up to the safe working loads in permissible wind pressures specified in the appropriate British Standard.

2) *Out of service*. With the crane not required for use or out of use when wind pressures exceed those permitted for in-service conditions, and without load on hook.

sleepers

1) *General*. Ground supports for rail tracks.

2) *Scotch derrick sleepers (or lying legs)*. The horizontal structural members of a derrick crane which connect the crane sole plate at the bottom of the mast to the bottom end of the back stays (see Figure 29).

3) *Slewing*. The rotary motion of a crane jib or load about the centre of rotation (see Figure 1).

slewing centre

see “Centre of rotation”

slewing lock (swing lock)

a mechanical device (such as a pin or latch) to lock the crane upperworks positively against rotation in one or more positions relative to the lowerworks (See also “Swing brake”).

slewing ring

a bearing (or bearings) on which the slewing part of a crane rotates (see Figure 1 and Figure 18)

slewing tower

a tower which slews with the jib and is mounted on a slewing ring (see Figure 18)

sliding tower section

a section of tower which is supported within the top of the main tower of a crane, and which carries the jib, counter-jib and cat-head assembly. When additional sections are added to the main tower, the sliding tower can be raised within it to increase the height of the crane (see Figure 25)

sole plate (or pivot structure)

the structural base under the mast of a derrick crane which carries the slewing rack and the pivot about which the mast rotates (see Figure 29)

stiff leg derrick

american term for Scotch derrick (see Section 4)

stringer

see "Bowsill"

strut jib

a jib supported and located at its lower end and supported at its upper end by a suspension member, such as a tie rope (see Figure 14 and Figure 21)

suspension ties

see "Derricking ties"

swing brake (slewing brake)

a friction device to retard the slewing motion of a crane or to hold the crane upperworks against rotation in any desired position relative to the lowerworks. (See also "Slewing lock")

tagline rope (or steady rope)

a rope which may be fastened to a crane hook attachment to restrain spinning of the attachment

tail radius

the maximum distance between the centre of rotation and the rearmost point of the revolving upperworks (or superstructure) (see Figure 1)

telescopic cage

a cage which encircles the tower of a crane and is used to raise the jib/counter-jib/cat-head assembly when additional tower sections are to be added to increase the height of the crane (see Figure 25)

telescopic jib

a jib which incorporates extension elements in the basic jib structure. The jib length can be extended (or shortened) by a telescoping motion (see Figure 14)

telescopic tower

a tower which is composed of two or more main sections which nest into each other and enable the height of the tower to be altered by a self-powered procedure (see Figure 18)

tie bars

see "Rail ties"

tie frames

frames by means of which ties can be attached to the tower of a tower crane (see Figure 26)

ties

means by which the tower of a tower crane can be braced from an adjacent structure to enable its free-standing height to be exceeded (see Figure 26)

tipping

see "Condition of tipping"

tower

that part of the structure of a tower crane which provides elevation and support for the jib mounting. The tower may or may not slew with the jib. (Types of tower are shown in Figure 18.)

tower crane

see Section 3

tower-head

the uppermost part of the main tower of a crane. On a fixed mono-tower the tower-head is immediately beneath the slewing assembly which it supports (see Figure 18)

track centres

- 1) *Crawler-mounted cranes.* The distance between the centres of the crawler tracks.
- 2) *Derrick cranes.* The horizontal distance between the centres of each pair of track rails (see Figure 30). (See also "Rail centres".)

travelling

self-propelling movement of a crane along the ground or track (see Figure 1)

trolley

see "Saddle"

trolleying (or racking)

the movement of the saddle (or trolley) along a jib to vary the hook radius

upperworks (or superstructure)

the upper part of a crane which can slew (or rotate) about a vertical axis (the centre of rotation) relative to the non-rotating mounting or lowerworks

wedges

means of securing the tower within tie frames or climbing frames (see Figure 26)

1.3 Legislation

Statutory regulations relating to cranes are contained in the following:

Factories Act 1961.
 The Construction (General Provisions) Regulations, 1961.
 The Construction (Lifting Operations) Regulations, 1961.
 The Construction (Lifting Operations) Certificates Order, 1962.
 The Construction (Working Places) Regulations, 1966.
 The Docks Regulations, 1934.
 The Ship Building and Ship Repairing Regulations, 1960.
 Mines and Quarries Act, 1954 (and General Regulations made thereunder).
 Motor Vehicles (Construction and Use) Regulations, 1969.
 Road Traffic Regulations Act, 1967 (Chapter 76).
 Motor Vehicles (Authorisation of Special Types) General Order, 1969.
 Road Vehicles Lighting Regulations, 1971.
 The Motor Vehicles (Rear Markings) Regulations, 1970.
 Factories Act (Northern Ireland), 1965.
 The Construction (Lifting Operations) Regulations (Northern Ireland), 1963.
 The Docks Regulations (Northern Ireland), 1934.
 The Ship Building and Ship Repairing Regulations, 1960.

1.4 British Standards

The following British Standards relate to cranes referred to in this Code of Practice and certain accessories and attachments used in lifting operations.

1.4.1 Cranes

BS 327, *Power-driven derrick cranes*.
 BS 357, *Power-driven travelling jib cranes (rail-mounted low carriage type)*.
 BS 1757, *Power-driven mobile cranes*.
 BS 1761, *Single bucket excavators of the crawler-mounted friction-driven type*.
 BS 2573, *Permissible stresses in cranes — Part 1: Structures*.
 BS 2799, *Power-driven rail-mounted tower cranes*.
 BS 3810, *Glossary of terms used in materials handling — Part 4: Terms used in connection with cranes*.

1.4.2 Accessories and attachments

BS 302, *Wire ropes for cranes, excavators and general engineering purposes*.
 BS 461, *Bordeaux connections*.
 BS 462, *Bull dog grips*.
 BS 463, *Sockets for wire ropes*.
 BS 464, *Thimbles for wire ropes*.
 BS 590, *Mild steel chain Grade 30, short link and pitched or calibrated for lifting purposes*.
 BS 1290, *Wire rope slings and sling legs*.
 BS 1663, *Higher tensile steel chain Grade 40 (short link and pitched or calibrated) for lifting purposes*.
 BS 2830, *Suspended safety chairs and cradles for use in the construction industry*.
 BS 2902, *Higher tensile steel chain slings and rings, links alternative to rings, egg links and intermediate links*.
 BS 2903, *Higher tensile steel hooks*.
 BS 3017, *Mild steel forged ramshorn hooks*.
 BS 3032, *Higher tensile steel shackles*.
 BS 3113, *Alloy steel chain Grade 60. Short link for lifting purposes*.
 BS 3458, *Alloy steel chain slings*.
 BS 3551, *Alloy steel shackles*.

1.4.3 General

CP 94, *Demolition*.

1.5 General considerations

Cranes are used under a wide variety of conditions but the following minimum requirements generally apply:

- 1) A test certificate should be available for the crane, as constructed, before the crane is put into service. Further tests will be required following repairs or substantial alteration, or periodically as prescribed by legislation. All test certificates or copies of certificates, and related documents should be with the crane or be available on the site of operation.
- 2) Periodic examination and inspections, systematic maintenance, repairs, renewals and any necessary heat treatment of lifting tackle should be carried out and recorded. Records should be with the crane or be available on the site of operation.
- 3) Cranes and lifting attachments should be clearly marked with their safe working loads and means of identification and should not be overloaded, except by a competent person for the express purpose of a test.

1.6 Recommended requirements for driver, slinger and signaller

1.6.1 The crane driver should:

- 1) Be more than 18 years of age.
- 2) Be medically fit, with particular regard to eyesight, hearing and reflexes.
- 3) Have the stature to enable him to operate the crane safely.
- 4) Have been adequately trained in the operation of the type of crane he is driving and be able to judge distances, heights and clearances.
- 5) Have been authorized to operate the crane.
- 6) Have sufficient knowledge of the working of the crane to enable him, as may be instructed, to carry out routine checks as specified in 1.10.2.
- 7) Understand fully the duties of the slinger and be familiar with the signal code shown in Figure 8 in order to implement safely the instructions of the slinger (or banksman) or signaller.

1.6.2 The slinger should:

- 1) Be more than 18 years of age.
- 2) Be medically fit, with particular regard to eyesight, hearing and reflexes.
- 3) Be agile and have the physique to enable him to handle lifting equipment and tackle.
- 4) Have been trained in the general principles of slinging and to be able to establish weights and judge distances, heights and clearances.
- 5) Be capable of selecting tackle and lifting gear suitable for the loads to be lifted.
- 6) Understand the signal code shown in Figure 8 and be able to give clear and precise signals.
- 7) Be capable of directing the movement of the crane and load in such a manner as to ensure the safety of personnel and plant.

1.6.3 Where the slinging of a load is not visible or not clearly visible to the crane driver, a signaller should be employed to relay the slinger's instructions to the driver.

The signaller should:

- 1) Be more than 18 years of age.
- 2) Be medically fit, with particular regard to eyesight, hearing and reflexes.
- 3) Understand the signal code shown in Figure 8 and be able to transmit the instructions of the slinger (or banksman) in a clear and precise manner.
- 4) Be easily identifiable to the crane driver (by wearing "high-visibility" clothing, or other means).

1.6.4 The driver, slinger and signaller should all be aware of the respective responsibilities of each, which should be clearly defined by the competent person in charge of the lifting operation. Where the signaller may be out of plain view of the driver, suitable telephone or radio communications will be necessary.

1.7 Choice and selection of crane

The Sections of this Code cover the classes of crane most commonly used on construction work and for general load-handling operations. Each class of crane possesses certain basic characteristics which will usually dictate the one most suited to a particular application.

1.7.1 **Mobile cranes** (*see 2.7*). Mobile cranes are suitable where on-site or between-site mobility is a primary requirement or where the job duration is short. Mobile cranes are usually adaptable to a wide variety of job applications and environmental conditions.

1.7.2 **Tower cranes** (*see 3.7*). Tower cranes are suitable for handling of relatively light loads to extremes of height and reach, particularly where the space for crane standing is confined.

1.7.3 **Derrick cranes** (*see 4.7*). Derrick cranes are suitable for handling of relatively heavy loads at long radii and where the duration of operations justifies the setting up and installation of the crane.

1.7.4 Each of the above classes of crane is available in a number of different types and the characteristics of the various machines available should be considered against the job requirements in selecting the type, number and size of crane(s) to be used for a particular application. Points to be considered in making the selection include:

- 1) Weights and dimensions of loads.
- 2) Heights of lift and distances/areas of movement of loads.
- 3) Number and frequency of lifts.
- 4) Length of time for which the crane will be required.
- 5) Site conditions, including ground conditions for crane standing, and space available for crane access, erection, operation and dismantling.
- 6) Any special operational requirements or limitations imposed.

1.7.5 Reference should be made to the relevant clauses of the appropriate Section of this Code for details of the different types of crane and their operational characteristics.

1.7.6 Having decided upon the type of crane to be used on a site and knowing the overall requirements to be involved, a machine having a working margin in respect both to load radius and maximum hook height should be selected.

1.8 Siting of cranes

In siting a crane for operation particular attention should be given to two factors; the crane standing or support conditions and the presence of proximity hazards.

1.8.1 Crane standing or support conditions.

The ground or foundations, temporary supporting structure, grillages, packings, connections and anchorages for cranes should be of sufficient strength to withstand the maximum loadings imposed in-service and out-of-service without failure, and settlements or deflections which might endanger the stability or safety of the machine. The siting of the crane, the assessment of maximum loads and the design of foundations, supporting structures and ancillary details should be approved by a competent engineer. Particular care should be taken to ensure that the imposed loadings are not underestimated and also a careful assessment of probable wind pressures should be made, taking into account the degree of exposure of the site and any other special factors. Crane manufacturers' data relating to the dead weight of the crane and the dynamic forces which can occur during operation of the crane, should always be obtained.

Under working (in-service) conditions, the loads imposed on the crane standing or support are usually due to the combined effects of:

- 1) the dead weight of the crane (including any counterweight and/or ballasting);
- 2) the dead weight of the load and any lifting attachments;
- 3) dynamic forces caused by movements of the crane and load during operation; and
- 4) wind loadings, resulting from operation in wind speeds up to the maximum permitted for in-service conditions, acting in any direction on the crane and load.

When out-of-service, the loads on the crane standing or support are imposed by the dead weight of the crane (including the counterweight or ballasting) combined with the wind loadings, acting in any direction, due to the maximum wind pressures anticipated on the particular site as specified by a competent engineer.

Particular care should be taken to estimate dynamic loads arising during operation for which data should be obtained from the crane manufacturer. A generous margin should be allowed for unpredictable effects.

When cranes are mounted on temporary elevated structures, it is essential that due account be taken of torsional reactions arising from slewing of the crane with load.

The overall stability and safety of a crane should be carefully checked in relation to local conditions and particularly when the crane must operate close to excavations or embankments, or on soft or sloping ground, or in tidal or floodwater areas, or over or adjacent to cellars or embankments, or on bridge decks, or partially completed building frames or other structural supports. These matters are further considered in **2.8.2** and **3.8.2**.

The analysis of the forces imposed by a crane on its standing or support is a vitally important matter which should always be checked by a competent engineer. The vertical and horizontal forces imposed are not uniformly distributed; their magnitude may be much greater than the loadings which cause them and will vary according to the position and movement of the crane and load and the direction and speed of the wind. Although crane manufacturers' instructions may specify maximum wind speeds for service conditions, they cannot give recommendations for survival wind conditions on a particular site. On tall cranes, wind forces will have a considerable influence on the strength requirements of the supports and foundations and the greatest care is necessary in the fitting-up and fixing of any holding-down devices, rail clamps, temporary connections or anchorages.

1.8.2 Proximity hazards, etc. Consideration should also be given to the presence of proximity hazards such as overhead electric lines or conductors, nearby structures or other cranes, public access areas including highways, railways and rivers, etc. Nor should the danger to or from underground services, such as gas mains or electric cables, be overlooked. Precautions should be taken to ensure that the crane standing is clear of any underground services or, where this is not possible, that the services are adequately protected to safeguard against any damage being caused.

1.8.3 Overhead electric lines and cables. Many fatal accidents have occurred from some part of a crane touching, or even coming near to overhead electric lines or cables, *without actually touching*. Wherever a crane must operate in the vicinity of, or travel under overhead lines or cables, the District Engineer of the local Electricity Board or Generating Board should be consulted well in advance of the start of any operations. He will advise on safety precautions or arrange to disconnect the supply and make the line dead.

In the absence of this expert advice a safe general rule for crane operations is to position the machine no closer to the plumb of the nearest line or cable than a distance equal to the length of the crane jib fitted, plus six metres (twenty feet) measured along the ground (see Figure 2). It should be noted that in certain cases of overhead lines with long spans, the line may swing laterally due to the wind. Allowance should be made for this to maintain the safe clearance distance at all times.

There are certain proprietary devices available, which are designed to be fitted on cranes and to give warning when the crane jib comes within a pre-determined distance of the power line. Such devices have limitations and the principles outlined above should be followed irrespective of whether a proximity warning device is fitted or not.

Where a crane must travel underneath an overhead line the crossing route should be plainly marked and "goal posts" erected each side of the crossing approach, to ensure that the jib or moving parts are lowered to a safe position (see Figure 3).

The dimensions of the goal posts and their distance from the nearest power cable is to be decided in consultation with the District Engineer of the local Electricity Board. Large notices should be posted stating:

"DANGER. OVERHEAD ELECTRIC LINES"

Crossing routes should be located as close to the power line support tower or pole as possible, in order to take advantage of the greater ground clearance.

When working parallel to overhead power cables, a string of warning markers should be erected at a safe distance from the cables. The string should be supported on posts at convenient intervals and each post should carry the warning notice described above.

Additional to the above, notices should be inserted in the driver's cab of all cranes likely to operate in the vicinity of overhead electric lines and cables stating:

WARNING. When working near overhead electric lines or cables unless otherwise agreed by the District Engineer of the local Electricity Board, the crane should be positioned no closer to the plumb of the nearest line or cable than a distance equal to the length of the crane jib fitted, plus 6 metres (20 feet) measured along the ground. Failure to comply with these instructions can kill you and/or other people working in the vicinity of your crane. If in doubt or difficulty consult the local Electricity Board Engineer.

Never travel a crane in the vicinity of overhead electric lines unless guided by an experienced banksman or slinger. Always try to keep the overhead lines in view when manoeuvring the crane, but remember it is difficult to estimate the heights or clearance distances of the lines by normal methods of observation.

If at any time the machine makes electrical contact with a live overhead electric line observe the following precautions:

- 1) Remain inside the cab.
- 2) Tell all other personnel to keep away from the machine and not to touch any part of the crane, rope or load.
- 3) Try, unaided, and without anyone approaching the machine, to back off the crane until it is well clear of the power line.
- 4) If the machine cannot be self-propelled away or disentangled from the line, remain inside the machine. If possible, get someone to inform the Electricity Board at once. Take no action until they confirm that conditions are safe.
- 5) However, if it is essential to leave the cab because of fire or some other reason then, to avoid being electrocuted, *jump* clear as far away from the machine as possible and avoid touching the machine and the ground at the same time. The District Engineer of the local Electricity Board or Generating Board should be informed of the situation immediately, but until assistance is received an attendant should remain near the crane to warn of the danger."

1.9 Erection and dismantling

Accidents frequently occur during crane erection and dismantling operations due to failure to follow the correct procedures specified by the crane manufacturers, use of incorrect parts, the wrong size or type of bolt, or the incorrect assembly or sequence of assembly or taking apart of components. To avoid dangerous and expensive consequences the following points should be observed.

1.9.1 Identification of machine components.

All jib sections should be clearly marked to identify the correct sections to be used for the crane and to prevent incorrect assembly. It should be noted that certain regulations require the jib of a crane to be identified with a specified machine. The materials of construction should be indicated on each jib section. Special bolts, such as high tensile steel bolts should be clearly marked and used where specified. Care should be taken not to intermix imperial (British threads and inch-sized) and metric (metric threads and millimetre-sized) fasteners such as nuts and bolts.

1.9.2 Manufacturers' instructions. It is essential that crane manufacturers' instructions be strictly adhered to. Any departures from the specified procedures may impose excessive loadings on structural and mechanical parts leading to a failure or collapse of the crane. It should always be ensured that:

- 1) The manufacturer's instruction book is available to erection staff.
- 2) The correct instruction book, appropriate to the particular crane, is used. (This should bear the manufacturer's machine serial number *and* the owner's plant number.)
- 3) The erection or dismantling operation is supervised by a competent person.
- 4) Erection staff are fully briefed and familiar with the prescribed procedures.
- 5) Before any departure is made from the prescribed procedures this is checked with and approved by the crane manufacturer.
- 6) Only correct parts and components are used.

1.9.3 Ropes. General comments on the installation, use and maintenance of ropes are given in **1.13**.

1.9.4 Electrical supply. The following points should be noted.

- 1) *Earthing.* Electrically-operated cranes should have an effective earth connection. In the case of rail-mounted cranes where the rail track forms part of the earthing circuit, at least one track should be electrically bonded at each joint and the track effectively earthed.

- 2) *Supply voltage.* Before connecting the crane to an electrical supply, it should be ensured that the supply voltage characteristics correspond with those of the crane equipment.

- 3) *Connections.* When possible the supply to a travelling crane should be through a cable winding drum or a properly installed and protected collector system.

If a trailing cable is used it should be mechanically protected, such as with wire armour, and incorporate an earthing core, and should be suitably terminated at each end. Care should be taken to ensure that the trailing cable is not damaged during operational movement or when travelling the crane.

- 4) *Isolation.* In addition to any isolator within the crane capable of cutting off the supply to the crane motions, there should be an isolator remote from the crane which can be used to cut off the electrical supply to the crane itself.

1.10 Procedures and precautions

1.10.1 Leaving the crane unattended. In no case should a crane be left unattended, even for short periods, unless all loads have been removed from the hook and the electric power supply switched off, or the engine stopped, and appropriate motion brakes and locks have been applied to put the machine in a safe condition. For longer periods and for out-of-service conditions, isolation should be more permanent, i.e. switches locked off, fuel supplies cut off and any doors giving access to machinery or control cabs locked to prevent unauthorized access. The ignition key and any other keys should be removed from the crane at any time when the driver is absent from the machine.

For details of methods to safeguard particular types of cranes, reference should be made to the appropriate Section of this Code, and the crane manufacturer's instruction book.

1.10.2 Routine checks. At the beginning of each shift or working day, the driver, if competent for the purpose, or other competent person, should carry out routine checks including the following:

- 1) Check that the automatic safe load indicator is correctly set and/or fitted with the correct cam appropriate to the jib length, or jib and fly-jib lengths and falls of hoist rope.
- 2) Check that the correct load-radius scale appropriate to the jib (or fly-jib) length is fitted on the visual indicator.

- 3) Check the security of the counterweight or ballasting. Where this is in the form of removable weights, check that the weights fitted correctly correspond to those shown on the counterweight chart for the operating condition in use.
- 4) Check the oil level(s), fuel level and lubrication.
- 5) Check the ropes, and rope terminal fittings and anchorages for obvious damage and wear.
- 6) Check the condition and inflation pressure(s) of tyres (where applicable).
- 7) Check that all water is drained from any air reservoirs.
- 8) Check the jib structure for damage.
- 9) In the interest of safety and fire prevention, check that the crane cabin is in a tidy condition and free from tins of grease and oil, rags, tools, or materials other than those for which storage provision is made.
- 10) Check the operating pressures in any air and/or hydraulic system(s).
- 11) Check the operation of the crane through all motions with particular attention to brakes to ensure that these are operating efficiently.
- 12) Check the operation of all limit switches or cut-outs (use caution in making the checks in case of non-operation).

1.10.3 Reporting of defects and authorization for use. Should the driver or maintenance staff find any defect or abnormality in the crane or in the operation of the crane, or should the crane be accidentally damaged, this should be reported immediately to the person responsible for the safe use of the crane. The machine should be taken out of service until the faults have been corrected and/or clearance is given by the responsible person.

1.10.4 Permit to work. Before any repairs, adjustments or inspections are carried out on a crane, a proper system of granting permission to work should be followed. Such a permit-to-work system properly implemented will ensure that the necessary precautions are taken to make the crane safe for maintenance or repair work, etc. (e.g. by isolation of electrical equipment, removal of ignition keys, etc.) and will notify all affected persons that the crane may not be used.

A permit to work is a specially designed form issued only by a responsible person which indicates that special precautions have been taken to make it safe for work on the machine to proceed for a specified period of time. The form may also specify any additional precautions which should be observed by persons carrying out the work.

The responsible person charged with the certification and issue of the permit should be the person in charge of the site operations and the permit should be issued to the person in charge of those who are to carry out the work. The issuer and receiver should never be the same person.

In the design of the permit it is usual to make provision for the signatures of the person actually to perform the work, and his foreman, thereby indicating that they have read and understood the conditions and any limitations of work imposed by the permit.

Most systems require that the person performing the work should retain the permit in his possession while carrying out this work. Where several persons are involved on the same job, the permit should be held by the senior person (e.g. a foreman). A commendable practice in this respect is for the permit to be placed in a specially designed carrier and hung in a prominent position on the crane involved, such as on the access door or at the crane driver's station, to indicate that men are working on the machine.

The permit will remain in force until the expiry of the time limit (if any) or until the end of the day or shift. A permit is not transferable and, for longer jobs, a new permit is required for each day or shift and whenever there is a change of labour on the job.

When the work is completed all permits should be returned, duly endorsed, to the person who issued them before the crane is "handed over" for normal use. This part of the procedure is just as important as the original certification, in that the responsible person in charge should ensure that all persons who were working under the permit are now clear of the machine or area, that any items of equipment brought in for that work have been removed, that all guarding and other safeguards on the crane have been replaced and that the machine is in all respects safe for normal use, subject to the conditions specified in 1.5 1), 1.5 2) and 1.12.

1.10.5 Safe means of access. There are statutory requirements that safe means of access shall be provided to the driving position of the crane and to enable inspections and maintenance work to be carried out. Personnel should be instructed to use only the proper means of access provided.

1.11 Safe working loads and operational conditions

1.11.1 Safe working loads. The safe working load of a crane is the maximum load UNDER SPECIFIED CONDITIONS for which a crane may be used. Safe working loads are generally calculated as a percentage of the ultimate load of a crane. The ultimate load will be the tipping load for certain cranes but for others a structural failure would occur before the crane reached a tipping condition, and, in these cases the ultimate load will relate to the manufacturer's design capacity of the crane. The margin between the safe working load and the ultimate load is a safety margin to allow for the various forces which will act on the crane in operation. These include allowances for wind loading and for dynamic forces set up by normal operational movement of the crane and load. Care should be taken during operation of a crane to avoid sudden snatching or stopping of the suspended load. Care should also be taken to prevent pendulum swinging of the load by careful control of the operating motions to match the swing of the load and to keep it under control at all times beneath the jib point (see Figure 4).

Crane manufacturers' safe working loads apply only to machines which are standing or installed on a LEVEL, FIRM AND UNIFORM supporting surface (see 1.8.1). Failure to meet these conditions may be dangerous. Maximum wheel, outrigger, track or base loadings should be ascertained and catered for. The stability of a crane may be much reduced when operating on a slope and this should be avoided (see Figure 5 and 2.8.2.2). A level indicator should be available on site and preferably fitted on the crane. A published load-radius dimension is the radius of the hook WITH THE SAFE WORKING LOAD suspended, unless otherwise specified. When a load is picked-up, owing to the stretch in the loaded jib suspension ropes and/or deflection of the jib structure, the hook radius will increase. With near-maximum safe working loads this increase may take the load outside the permitted radius and before the lift is made the jib should be derricked-in to bring the load back into radius, as necessary (see Figure 6). Conversely when settling down loads with the jib positioned at steep angles, it should be ensured that the jib is not damaged by contacting the "closed" jib safety backstops or by extreme tensioning in the jib safety guy ropes. Sudden setting-down or release of loads should always be avoided in order to prevent the jib springing backwards or the machine becoming unstable in a backwards direction.

Safe working loads apply only to freely-suspended loads. It is expressly forbidden to use the crane hook or slewing motion of a crane to drag any load along the ground, etc. Also before lifting a load the hoist line should be plumb (see Figure 7). Failure to observe these points may hazard the stability of the crane or introduce loadings (stresses) into the jib for which it has not been designed and even with an automatic safe load indicator fitted, a structural failure may result without any warning being given.

Published safe working loads generally include the weight of the hook block and/or load lifting attachment(s) and in such cases the weight of these should be deducted to obtain the nett working load.

Crane manufacturers' safe working loads are based on and apply only to cranes in good condition. It should be ensured that the jib structure is not damaged with structural members bent or kinked. If the jib structure is damaged or should become damaged in service, such as might occur if the load strikes the jib, the driver should report this at once to his supervisor.

Reference should always be made to the crane manufacturer's handbook or appropriate machine specification to establish the restrictions, limitations or special conditions applicable to a particular crane.

Further reference should be made to the relevant clauses of this Code dealing with safe working loads for different types of crane and to the factors affecting safe working loads.

1.11.2 Mode of operation and control. Each crane control should be clearly identified to show the motion and direction of movement and, when practicable, should be so arranged to prevent inadvertent operation.

Before starting any lifting operation with a crane, the driver should ensure:

- 1) that he has a clear and unrestricted view of the load and operational area. If not, he should act under the directions of the slinger or an authorized signaller who is positioned to have such a clear and uninterrupted view;
- 2) where telephone or radio communications are being used, that the calling signal is functioning and that verbal messages can be clearly heard;
- 3) that all gauges are reading correctly and that air or hydraulic systems are up to operating pressure.

When handling loads which approach the maximum working load for an operating radius, crane motions should be operated with extreme care. The load should initially be lifted just clear of the supporting surface and brought to rest while the slings, balance of the load, etc., are checked, before proceeding. Proper care should be exercised by the driver, at all times, to avoid shock or side loadings on the jib. Care should also be taken to avoid the hook contacting the jib head structure, either through overhoisting or when derricking out the jib. In the latter case, as the jib is derricked out the hook should be lowered off in order to maintain an adequate clearance.

During normal operations if it is necessary to hold a load suspended for any period of time, the driver should remain in the driving position. The machine should be fully operational to meet any emergency arising but with the hoist brake lock, the boom derricking safety pawl and the swing lock/brake, where fitted, all engaged. Under no circumstances should the crane be left unattended with the load suspended.

1.11.3 Ropes. See 1.13.

1.11.4 Handling of loads near persons and carrying of persons

1.11.4.1 *Handling of loads near persons.* When loads have to be handled in the vicinity of persons, extreme care should be exercised and adequate clearances allowed.

Lifting of loads over highways, railways, rivers or other places to which the public have access should be avoided. If this is not possible, permission should be obtained from the appropriate authority and the area kept clear of traffic and persons.

1.11.4.2 *Carrying of persons by crane.* The carrying of persons by crane is subject to certain statutory regulations. (See Regulation 47 of the Construction (Lifting Operations) Regulations, 1961.) Requirements include provision of a properly designed safety chair or suitable skip or cradle. Skips which can tip should not be used. It is recommended that personnel should not be lowered other than by an engine-power-controlled load-lowering mechanism.

1.11.5 Tandem lifting. Lifting a load with two cranes is a potentially dangerous operation which should be avoided except where the physical dimensions, characteristics or weight of the load prevent this being handled by a single crane. The operation requires extremely careful planning and an accurate assessment of the share of the load which is to be carried by each crane. There should be a full appreciation of how and to what extent this can vary should the load come out of level or should one or both cranes have to derrick, travel or slew, resulting in the hoist ropes coming out of plumb.

If any of these circumstances occur an additional load can be thrown on either or both cranes which may affect crane stability or cause a structural collapse.

Special lifting tackle may be also necessary to suit the maximum variation in load distribution and direction of application which can occur during tandem lifting.

All tandem lifting operations should be thoroughly planned in advance by a competent person. Where possible cranes of equal capacity and similar characteristics should be used. The cranes and lifting tackle to be used should be selected to have a capacity margin greater than that needed for the proportioned load when handled as a single lift. It is recommended that the safe working load of each crane for the required jib length and operating radius should be at least 25 % in excess of the calculated share of the load to be handled by each crane during the tandem lift.

A competent person should be specially appointed to supervise the operation, and the signals to each crane driver should be clear and well rehearsed.

Multiple lifting operations using more than two cranes are not recommended.

1.11.6 Special duties. In all cases involving special duties manufacturers' guidance should be obtained.

1.11.6.1 *Grabbing and magnet crane service.* When using cranes for special duties such as grabbing or magnet crane service, allowance should be made not only for the weight of the grab, magnet or other attachments, together with lead, but also for additional loadings imposed on the crane resulting from fast slowing, grab suction effects, impacts, etc. In general, for grabbing or magnet crane service the weight of the grab and contents, or the weight of the magnet and lead will be less than the corresponding safe working loads for crane service. Reference should be made to the manufacturer's specification for details of special duty ratings for any machine.

1.11.6.2 Demolition ball service. In this service a round or pear-shaped weight, known as a demolition ball, is suspended from the hoist rope of a crane and caused to move to strike the building, structure or other object to be demolished so that the impact causes collapse.

By the nature of demolition ball service, dynamic loadings are imposed on the jib structure and other parts of the crane by the movement and impact of the ball. In rating a machine for this service, the crane manufacturer will assume certain dynamic loading values, but in practice the magnitude of these will vary widely according to the method of using the demolition ball, the skill of the operator in controlling the ball and the impact resistance of the building being demolished. Manufacturers' recommendations and working loads should, therefore, be regarded only as a guide. Lesser loads and/or shorter jibs should be adopted by the demolition contractor in the light of his practical experience in the use of the particular machine in similar applications and according to the technique adopted and proven skill of the operator.

In practice three operational techniques are used in demolition ball service.

1) *Vertical drop ball.* The ball is suspended above the building to be demolished and the holding brake released allowing the ball to fall vertically under gravity onto the building. Sudden braking to arrest the fall should be avoided as this is likely to result in overturning of the machine or cause a structural failure.

2) *Swinging the ball in line with the jib.* An additional rope from a second drum on the crane is attached to the ball and is used to pull the ball in towards the machine. The pulling rope is then released allowing the ball to pendulum outwards, in the plane of the jib, to strike the building. The second rope is used to control and limit the outward swing of the ball. Care should be taken to ensure the stability of the crane is not hazarded.

3) *Slewing jib.* By this technique the demolition ball is suspended some distance below the jib head and the slewing motion of the crane is engaged causing the ball to swing in an arc and strike the building. When using this technique high torsional and side loadings can be imposed on the jib structure in its plane of least strength. For a given weight of ball and attachments, the actual stress levels set up in the jib structure will be governed by a number of factors including:

- a) length of jib and operating radius;
- b) distance of ball below the jib head;
- c) rate of acceleration of slewing motion;

d) speed of ball at impact and the impact resistance of the building or structure;

e) position of the jib head relative to the demolition ball when the ball strikes the building;

f) rate of checking of slewing motion.

The drivers of cranes engaged in demolition ball service should be not only skilled and experienced in the use of the equipment and techniques of demolition, but also familiar with the machine in use and aware of the potential dangers and their possible cause. Operational methods should be used which do not overstress the jib or hazard the stability of the crane. There should be a high standard of inspection and maintenance of the machine, jib, ropes and all attachments.

It should be noted that certain manufacturers do not recommend use of their machines for demolition ball duties or may only approve this conditionally such as with restriction in the technique to be followed, the maximum jib length to be used, etc.

The use of swinging ball demolition techniques should be restricted to machines designed for arduous or heavy-duty service, such as convertible dragline excavators. For a required ball weight and working height, only a machine of excess capacity both in respect of working load *and* jib length should be used. The shortest practical length of jib, within the manufacturer's recommendations, should be adopted at all times, reducing the length of jib if possible as the demolition proceeds and the working height diminishes.

An anti-spin swivel should always be fitted between the hoist rope and demolition ball to prevent twisting of the rope. Also where the technique involves swinging the ball, a restraining/controlling rope from the second drum of the machine should be attached to the ball to prevent it swinging out to a radius which might hazard stability. The jib derricking mechanism should not be used for swinging the ball.

Care should be taken to prevent the ball striking the jib structure or buildings other than that to be demolished. As a protection against the jib springing over the cab on release of the ball, jib angles greater than 60° from the horizontal are not advisable for demolition ball operations. Jib safety stops should always be fitted on the crane and adequate protection against flying debris provided for the driver.

In all cases the demolition ball should only be used when the crane is standing stationary on firm and level ground. Generally the equipment should be used from outside a building and not from the inside. When demolishing masonry arches, suspended floor slabs, etc., care should be taken to avoid the ball becoming trapped, as a sudden collapse of the structure could overload the crane. If the ball does become trapped, it should be lowered off before being freed as a dragging or lifting action might cause the structure to collapse on top of the ball, so pulling the crane over.

Cranes equipped for vertical dropball operation are also used in applications other than demolition. These include their use in the secondary breaking of blasted material in quarries or for slag breaking in steelworks operations. In these other applications the same basic precautions should be applied.

1.11.6.3 Piling service. Although a number of different techniques are used in piling operations the objects, in most cases are the same; to position a pile in the ground either to carry superimposed vertical loads (bearing piles) or to resist horizontal loads imposed by earth or water pressure (sheet piles). Pre-formed concrete or steel piles are usually driven into the ground by means of an impact or reciprocating hammer. Bored-pile techniques, with or without casings, may also be used in certain applications whereby the pile is cast in its location by pouring concrete into a hole driven or bored into the ground. A further feature of piling operations is the need, on occasions, to withdraw or extract the piles (or pile casing) once their useful purpose has been served.

Piling service necessitates the use of special equipment. Depending on the type or sophistication of piling, this equipment may either be in the simple form of a temporary attachment to a crane or, at the other extreme, may form a permanent special-purpose installation on a machine. In addition to the pile hammer or driver attached to the end of the hoist line, pile leaders or a piling frame may be suspended from the jib head to locate and guide the pile during the driving operation. It is essential to ensure that the additional weight of the piling equipment and the loads arising during operation do not overload the crane or jib structures or hazard the stability of the machine under any conditions of service.

By the very nature of piling duties the crane will frequently operate on or traverse over soft and uneven ground. Particular attention should be paid therefore to the standing of the crane during operation to guard against differential settlement of the crawler tracks or crane supports, which might adversely affect the stability of the machine (or the efficient driving of the pile). When travelling and steering the machine, precautions should be taken to prevent the suspended leaders or the piling frame from swinging and imposing excessive side loading on the jib.

Owing to the high impact or shock loadings which can be imposed on machines engaged in piling operations, it is essential that only cranes of adequate capacity and in first class mechanical and structural condition be used. The magnitude of the loadings imposed will depend to a large extent on the skill, knowledge and experience of the operator both in the techniques of piling and the capability of his machine. Frequent inspections of the crane and jib structures should be made by a competent person, with special attention being given to the welds on the jib. Any repairs found necessary should be effected immediately. Hoist and suspension ropes should also be frequently examined for wear or other deterioration and replaced as necessary.

Particular care should be given to examination of ropes lying round pulleys or on drums and to rope terminal fittings.

1) *Pile driving.* Where practical, adequate packing or support should be provided between the bottom of the leaders and the ground to give support to the leaders. When pitching a pile in position for driving, care should be taken not to impose excessive side loading on the jib. Side dragging of piles should be avoided. To minimize transmission of shock loads to the jib structure when a drop hammer is used, premature catching of the falling hammer or snatching the hammer following over-running of the rope on the hoisting drum, after the hammer has struck, should also be avoided.

If a drop hammer is used on a crane mounted on a barge or other floating plant, the hammer striking the pile is equivalent to sudden release of a load and produces a reaction on the vessel which should be taken into account in considering the stability of the unit.

2) *Pile extraction.* For pile extraction, an extractor, which is usually of reciprocating or vibratory type (and may be used either for driving-in or pulling-out piles) strikes the pile upwards and loosens its adhesion in the ground. The actual pull to withdraw the pile is done by the crane hoist line from which the extractor is suspended. Extraction should be effected by a “smooth” pull on the hoist line and under no circumstances should the hoist rope be jerked or the machine tipped to achieve faster results.

In view of the arduous nature of pile extraction it is strongly recommended that this service be restricted to machines designed for heavy-duty work such as convertible dragline excavators.

In assessing the required capacity of a crane for pile extraction duty, in addition to the weight of the extractor and pile, account should be taken of the frictional forces occurring between the ground and the pile during extraction. In the case of sheet pile extraction a further allowance is necessary for the friction between the clutches of the pile being extracted and the adjacent pile remaining in the ground. As the frictional effects are largely unknown factors, until extraction commences, the largest crane practicable will always give the safest and quickest results providing the pull does not exceed the extractor rating.

The length of jib used should be the minimum to provide the necessary headroom for the extracted pile and great care should, be exercised in ensuring that the standing of the machine is firm and level and the fall(s) of the hoist rope is vertical when the pull is applied. Any deviation from vertical could cause a structural failure due to an eccentric loading on the jib or could lead to failure of the web of the sheet pile resulting in sudden release of the hoist line so causing the jib to whip backwards. To guard against this it is recommended that an adequate safety bond, such as a chain, is shackled between the pile head and the extractor or crane hook. Some extractors have self-locking type wedge jaws to hold the sheet pile but when the operation includes lowering of the pile to the ground it is again recommended that a safety bond be fitted in case of accidental jaw release when the end of the pile touches the ground.

1.11.6.4 Special lifting attachments. The weight of the lifting attachments should always be included as part of the load to be lifted and deducted from the permissible safe working load. Attachments should be tested, certified and plainly marked with the safe working load and weight of attachment. They should only be used for the purpose for which they were designed. Vacuum lifting attachments should be regularly checked to ensure that adequate suction is maintained over the required period.

1.11.7 Weather conditions

1.11.7.1 Cranes are generally designed to operate in conditions of normal steady wind speed. Gusting wind conditions may have an adverse effect on safe working loads and machine stability. Even in relatively light wind conditions it is prudent to avoid handling loads presenting large wind-catching surfaces which might result in loss of control of the load or overturning of the crane despite the dead weight of the load being within the normal working capacity of the machine.

Any instructions issued by the crane manufacturers advising conditions under which a crane should be taken out of service and recommending the condition in which it should be placed, should be strictly followed.

A wind speed indicator or anemometer should be available on the working site. In the case of tower cranes the anemometer should be mounted at the highest point of the crane structure.

1.11.7.2 If the visibility or range of sight of the driver is impaired by snow, fog, or other adverse weather conditions, strict supervision of the crane operation should be exercised. Where appropriate crane operations should be temporarily suspended.

1.11.7.3 Brake or clutch units on all cranes should be protected against rain or other adverse weather conditions. Following shutdown periods and before starting lifting operations, all friction brakes and clutches should be cautiously test tried for efficiency to ensure freedom from moisture.

1.12 Testing

In most cases it is a statutory requirement that all cranes be tested by a competent person before being taken into use and periodically thereafter. In addition, a further test may be required following any substantial alteration or repair to the crane. Reference should be made to **1.15.1** and the schedule of legal requirements listed in Table 1.

1.12.1 Ballasting and anchorage test. Under the Construction (Lifting Operations) Regulations, 1961, after each erection of a crane or alteration affecting the anchorage or ballasting, tests should be carried out to establish the security of the anchorage and adequacy of the ballasting. These tests require the imposition of a 25 % overload above the appropriate maximum safe working lead to be lifted by the crane at a position where there is a maximum pull on each anchorage or by the imposition of a reduced lead at an increased radius to give an equivalent test of the anchorage or ballasting arrangements. When making these tests caution and care should be exercised to avoid the possible overstressing of crane components (see 1.9.2 and 1.12.2).

Records of this test are required to be entered in the appropriate register.

1.12.2 Overload test. An overload test generally requires the imposition of a lead, or loads, 25 % in excess of the safe working lead. An exception to this is the Dock Regulations, 1934, and the Ship Building and Ship Repairing Regulations, 1960, which stipulate the proof loads required. Before any overload test is carried out, it should be established that the design of the crane allows for the imposition of an overload and the amount and position at which such an overload may be handled. It should be noted that the maximum lead may be limited by the structural strength of the crane and not by the stability of the machine in which case a structural failure might occur, e.g. the jib might collapse, without warning, before the crane started to tip. Before a test is carried out reference should be made to a competent person or authority experienced in crane design and construction. Due account will then be made for the actual condition of the used crane at the time of re-testing. It should be noted that an overload test is not the sole criterion for assessing the safe working lead of a crane.

To protect the automatic safe lead indicator from possible damage, this should be disconnected during the period that the test overload is being applied to the crane. On completion of the test, the indicator should be re-connected and carefully checked to ensure correct functioning following which the appropriate certificate should be issued.

1.12.3 Automatic safe lead indicator test. Under the Construction (Lifting Operations) Regulations, 1961, automatic safe lead indicators on cranes require to be tested, using known weights, after erection, installation or removal likely to have affected the operation of the indicator. Automatic safe load indicators also require to be inspected at least once a week.

The tests on all cranes other than mobile cranes should be carried out by a competent person other than the driver. On a mobile crane the test may be carried out by the driver if competent to do so. The weekly inspection of indicators on all cranes may be carried out by the driver if competent to do so.

1.13 Ropes

1.13.1 Selection. Many factors influence selection of a wire rope for a particular application on a crane. The strength of a rope, although of major importance, is only one of these factors; it is essential therefore to use only ropes of the correct size, type and construction as specified by the crane manufacturer.

1.13.2 Rope reeving. Where it is possible to vary the number of falls of the hoist rope or parts of rope in the derricking system, it is important to ensure that these are in accordance with the crane manufacturer's recommendations for the heaviest load to be handled and for the particular jib length to be used. It should be noted that if an automatic load indicator is fitted, this will generally only operate accurately providing the indicator cam and/or setting corresponds with the length of jib fitted and the rope reeving adopted.

1.13.3 Rope lengths. It should be ensured that the correct length of rope is fitted. Particular care should be exercised on cranes with variable jib lengths as it may be necessary to change the rope and to fit a specific length of rope for a particular jib length and rope reeving combination. Too short a rope could result in the rope completely paying out, and all the load would be taken by the anchorage. (An extremely dangerous situation could arise following a rope or jib length change if the first lift is from an elevated position to ground level, e.g. in a dismantling operation.) Too long a rope may exceed the drum spooling capacity and result in the rope riding over the flanges and becoming trapped in the machinery causing severe damage and possibly premature failure.

After changing the length of jib, or the length and/or number of falls of the hoist rope, it is good practice to check the adequacy of the rope length before making the first operational lift. (This is particularly important where abnormal conditions occur, such as when a load is to be lowered to below ground level.) Before lifting operations commence the jib should be raised to its maximum working angle and the hook lowered to ground level or a lower point, if required, to ensure that at least two dead coils remain on the drum; then to the highest point to check that the drum capacity is not exceeded.

1.13.4 Rope handling and installation. Careless handling of a new rope can lead to damage, short life and unsatisfactory performance in service. Rope manufacturers' recommendations on rope handling and installation should be followed.

When installing a rope on a crane drum care should be taken to avoid kinking or twisting of the rope as this will damage the rope and will adversely affect spooling and may cause the vertical falls of the hoist rope to twist together during operation. Also to ensure correct initial spooling a tension should be applied to the rope as it is guided onto the crane drum.

If the rope is supplied in a coil, this should be uncoiled by rolling along the ground in the same way that a fireman runs-out a hose (see Figure 9a). Alternatively, a rope supplied on a reel should be uncoiled either by rolling the reel along the ground (see Figure 9b) or by rotating the reel mounted on a support axle (see Figure 9c). Under no circumstances should the rope be pulled from a coil (see Figure 9d) or reel (see Figure 9e) lying flat on the ground.

When it is necessary to lay a rope out on the ground care should be taken to ensure that the surface is free from any matter likely to be injurious to the rope.

1.13.5 Rope spooling. If at any time during crane operation the hoist rope is relieved of tension by over-lowering and the rope on the drum becomes slack and cross-coiled or trapped in part of the crane machinery, no further lifting operations should be undertaken until the rope has been payed out, examined for possible damage by a competent person and replaced or re-spooled correctly.

1.13.6 Rope guards. Where rope guards are fitted to pulleys or drums it is essential that these remain in their correct positions and are removed only for the purposes of maintenance, inspection or adjustment. This is of particular importance where, under certain circumstances, the rope system may be relieved of tension. Failure to observe this procedure may allow a rope to run off a pulley or drum and become trapped.

1.13.7 Guide rollers and pulleys. Rollers or guide pulleys are sometimes fitted on the jib to ensure that the rope does not rub against the jib structure. Where these are fitted it is essential to check frequently that they are free to rotate. A seized roller or pulley will cause serious damage to a rope, leading to its premature failure.

1.13.8 Rope drums and pulleys. Where drum/laggings are replaceable it should always be ensured that the correct drum or lagging is fitted for the size of rope used and the duty requirements.

Rope drums and pulleys should be examined at regular intervals for if they are badly worn this will have an adverse effect on rope life. Where replacement is necessary only items supplied or approved by the crane manufacturer should be fitted. Some designs may allow for drum and pulley grooves to be re-machined, but this operation should only be undertaken in accordance with the manufacturer's instructions. There is a limit to the amount of metal which can be removed before the strength of the component will be affected.

Pulleys should revolve freely on their supporting shafts and particular attention should be paid to lubrication.

1.13.9 Rope terminal fittings. Only rope terminal fittings as specified by the crane manufacturer should be used to attach a rope to a drum, hook block or the structure of the crane. Care should be taken to ensure that anchorage points are securely fastened in accordance with instructions.

Particular attention should be paid to wedge and socket fittings.

1.13.9.1 Assembly of wedge and socket terminal fittings for ropes. The following points should be noted.

- 1) It is essential to use only a wedge and socket of the correct size for the rope fitted. Failure to do so may result in the rope pulling through the fitting as soon as a load is applied.
- 2) Wedges and sockets for a particular size of rope obtained from different manufacturers may not be interchangeable owing to dimensional differences. The mixing of components obtained from different suppliers should be avoided and the fit of the wedge (with rope) in the socket should always be checked at the time of assembly. Too large a wedge or a wedge of incorrect taper will not sufficiently enter the socket to give a secure termination; too small a wedge will protrude too far through the socket and the local loading may cause the socket to crack and open out allowing the wedge to pull through.
- 3) The rope should be fitted so that the live or loaded part of the rope is not kinked where it leaves the socket, but pulls directly in line with the point of attachment of the socket as shown in Figure 10. Incorrect fitting will result in premature failure of the rope.
- 4) When making up the termination, a dead-end length of rope not less than 15 times the diameter of the rope should be left protruding from the socket, e.g. 190 mm (7½ in) dead-end length for a 13 mm (½ in) rope. If a rope with tapered end is used, the tapered section should be clear of the socket fitting.

5) After making or re-making a wedge-and-socket termination, it is essential that the wedge and rope are properly seated in the socket before the crane is put into service. Failure to do so may allow the rope to pull through the fitting or, particularly when using a new rope, the wedge to be sprung out of the socket.

Initially the wedge should be hammered home, protecting the fitting and rope against damage, by a wooden packer. Simultaneously a second man should be pulling on the ends of the rope. The jib should then be raised to a working position and a load suspended to firmly seat the wedge and rope into the socket before the crane is used operationally.

1.13.9.2 Inspection. Rope wedge and socket terminal fittings should be inspected weekly by a competent person. Particular attention should be paid to rope damage as might be evidenced by broken wires or deformation of the rope where it emerges from the socket; to the condition of the socket, i.e. that there are no cracks in the socket or deformation of the socket as might be expected if the wedge is seen to protrude excessively; and to the security and tightness of the wedge fitting.

The socket and wedge and part of the rope lying inside the fitting should be examined each time the socket is disassembled for any reason; such as to change the number of falls of the hoist rope, or at intervals not exceeding three months (or at more frequent intervals in the case of severe or arduous service applications). If necessary an undisturbed portion of the rope should be used when re-making the anchorage. Wedges found to be damaged by rope indentation should be replaced by new wedges of correct size for the rope in use. Sockets should be cleaned and carefully examined for cracks or other signs of damage and replaced as necessary.

1.13.9.3 Special care applications. Special care is necessary in any application where there is a possibility of the rope dead-end in a wedge-socket termination coming into contact with an obstruction which might loosen the wedge causing the rope to pull free. In such cases it is recommended that the dead-end length of rope is lashed to the live rope using soft wire binding.

1.13.9.4 Exceptions to use. The use of rope wedge and socket terminations is not recommended in any case where a crane hoist rope supports a man carrying skip or platform.

1.13.10 Examination of ropes. Thorough examination is necessary periodically to ensure the safety of rope systems. Ropes should be thoroughly examined by a competent person for wear, damage and corrosion. Particular attention should be paid to tucked splices and those sections of rope lying close to the terminal fittings. In the case of ropes which are composed of more than one layer of strands, such as non-rotating ropes, deterioration may occur internally at the interface between the layers and it is therefore essential that the rope is opened and the inner strands also examined. Where multi-layer drums are used, it is necessary to examine not only that part of the rope which is in constant use, but also the rope which may remain spooled and inoperative on the drum for long periods.

By the very nature of their function, jib and fly-jib suspension ropes are often situated at positions remote from the basic crane structure. It is essential that these ropes are carefully examined and particularly those sections of rope adjacent to fittings or lying round pulleys. Note should be made of possible effects due to climatic and environmental conditions; particularly where a crane is operating in a saline or other corrosive atmosphere. Wear is not normally a criterion for suspension ropes but the presence of abrasive dust in the atmosphere can contribute to wear. Nor should the possibility of damage be discounted as this may have occurred during erection and dismantling operations.

Current legislation requires examination of ropes at specified intervals and attention is drawn to the relevant sections contained in the regulations listed under 1.5.

1.13.11 Rope care and lubrication. New ropes will have been lubricated during manufacture and this lubricant will be adequate for initial storage and the early stages of a rope's working life. This initial lubrication may be supplemented at regular intervals with a dressing in accordance with the crane manufacturer's instructions or as approved by the rope maker. However, before a rope preservative dressing is applied it is essential that the rope is thoroughly clean and free from matter which may be injurious to rope life. Also consideration should be given to the environmental conditions in which the rope is to be used. In applications where driving sand, fly ash or abrasive dust may adhere to the treated surface, the rope manufacturers should be consulted before any dressing is applied.

1.13.12 Rope storage. Replacement or alternative ropes should be stored, preferably on reels, with the outer surface covered to protect the rope and prevent the ingress of water or matter injurious to the rope. Where storage is required over long intervals it is good practice to examine the ropes periodically and to apply dressing as necessary. Alternative ropes which have been removed from a machine should be thoroughly cleaned and dressed before being stored under clean and dry conditions.

1.14 Slings and handling of loads

1.14.1 Use of correct tackle. Only slings and tackle for which a valid test certificate has been issued and which have been thoroughly examined within the previous six months should be used. Slings and tackle should be clearly marked with the safe working load and an identification number (for test record purposes). All slings and tackle should be visually inspected on each occasion before use. When not in use such tackle should be maintained in a serviceable condition in a suitable store. Tackle should be released from the store only on the instruction of a responsible person.

When used in connection with the handling of molten metal or slag the safe working load of all lifting tackle should be de-rated to half the normal safe working load.

Chain(s) should not be joined by means of bolts or wire and when shackles are used it is essential that the proper pins be fitted. Under no circumstances should chains be knotted.

Chains and slings should never be dragged along the ground or floor.

1.14.2 Multiple-legged slings (see Figure 11). At the present time a revised method of specifying the safe working load for multiple-legged slings is being introduced. By this method a single value of safe working load will apply to multiple-legged slings for *all* leg angles up to normal maximum working limit of 90°. Reference to a chart to establish the safe working load for different leg angles will not then be necessary. The upper terminal fitting of assembled slings will carry an inscription giving the safe working load in kilogrammes (kgs) or tonnes (t) and also the permitted range of leg angles for which the slings may be used; e.g. 0° to 90°. The specific angle in the case of 3-leg slings is the included angle between any two adjacent legs and, for 4-leg slings, the included angle between any two diagonally opposite legs (see Figure 11a).

Until existing slings in use have been re-certified and marked in accordance with the new practice, the safe working load for multiple-legged slings should be established, as before, from a chart showing the permitted loads for different leg angles. Sling charts should be prominently displayed in the sling storage area and for site operations a copy of the chart should be carried on the crane. (Ideally this would be fitted on the crane in a suitable location for reference by the slinger or banksman; such as at eye level on the outside of the cab.) It should be noted that the safe working load of multiple-legged slings indicated in the charts assumes equal distribution of load between the legs of the sling. If the load tilts excessively when lifted, it should be put down and the slinging points further adjusted so that the load hangs level, i.e. the sling points are equidistant from the centre of gravity of the load (see Figure 11b).

The length of sling used should be sufficient to avoid requiring wide angles between the legs which, in any event, should not exceed the maximum angle specified. Where headroom does not permit use of long slings, a spreader bar should be used.

1.14.3 Rope slings. Although the practice is not recommended, if it is necessary to form the eye by the use of rope grips (bull dog grips), the grips should be attached with the “U” bolt side on the dead-end of the rope (see Figure 12). Where appropriate a rope thimble should be used when making a connection with grips to prevent bending the rope over too small a radius. As a general rule the centre distance between grips should be six times the diameter of the rope; the minimum number of grips used will depend on the diameter of the rope but should in no case be less than three. After a short period of service, nuts on a new grip attachment should be tightened. Grips should be inspected regularly thereafter to check that the nuts are tight and that the rope has not slipped.

1.14.4 Slings of special loads. When handling irregular-shaped loads, such as machine tools, where the position of the centre of gravity is not readily ascertained it is essential to determine this by trial and error without lifting the load completely off the ground. Having established this, the tackle should be adjusted to ensure that the load is evenly balanced for lifting without tendency to topple over, and that no part of the load is subjected to excessive strain which might cause damage to the load (see Figure 11b). Slings should be protected against any sharp edges on the load.

The weight of all slings, tackle and lifting beams should be regarded as part of the load to be lifted.