

Specification for

Power-driven tower cranes for building and engineering construction

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Federation of Civil Engineering Contractors	The British Transport Docks Board
Federation of Wire Rope Manufacturers of Great Britain	The Welding Institute
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Foreword

This British Standard, prepared under the authority of the Mechanical Engineering Industry Standards Committee, is a revision of BS 2799:1956 and forms one of a series relating to cranes and excavators. As with all other British Standards in this series, the primary object of the specification is to ensure reliability and safety without placing restrictions on the general design of cranes or methods employed in their construction.

This revision of the standard extends the scope of the first edition by embracing not only rail-mounted tower cranes but also types having static bases.

Other standards in this series are as follows:

BS 327, *Power-driven derrick cranes.*

BS 357, *Power-driven travelling jib cranes (rail-mounted low carriage types).*

BS 466, *Electric overhead travelling cranes for general use in factories, workshops and warehouses.*

BS 1757, *Power-driven mobile cranes.*

BS 1761, *Single bucket excavators.*

BS 2452, *High pedestal or portal jib cranes.*

BS 2573, *Permissible stresses in cranes — Part 1: Structures.*

BS 3579, *Heavy duty electric overhead travelling and special cranes for use in steelworks.*

Attention is drawn to the appendices, including Appendix C which contains a list of items of legislation affecting cranes. In addition, the attention of users of this standard is drawn to the Memorandum on the Electricity Regulations by the Senior Electrical Inspector of Factories (Form 928).

Where imperial unit equivalents are stated, the figures in metric units are to be regarded as the standard. The imperial conversions are approximate. More accurate conversions should be based on the tables in BS 350, "*Conversion factors and tables*".

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 42, an inside back cover 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 British Standard applies to power-driven cranes of the tower type as used on building sites and in works of engineering construction where the crane is dismantled when it has served its purpose.

Both horizontal jib and luffing jib cranes are included and they may be of the travelling, fixed or climbing type.

Figure 3, Figure 4, Figure 5, Figure 6 and Figure 7 show examples of various types of tower crane and ancillaries.

This British Standard is not intended to apply to power-driven mobile cranes, complying generally with BS 1757:1964 and fitted with tower or mast crane attachments.

NOTE The titles of the British Standards referred to in this standard are listed on the inside back cover.

1.2 Definitions

For the purpose of this British Standard the following definitions, together with those for basic stresses given in BS 2573-1, apply:

1.2.1 Ballast

dead weight added to the structure of a crane to secure stability

1.2.2

blocking up base

the effective span of the supporting base when outriggers or other means are used to increase stability

1.2.3

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

1.2.4

clearance lines

lines defining the area within which the crane should be designed to work with suitable clearances. Buildings or other structures must not encroach within these lines

clearance lines should be related to the positions of the crane rails, ground level or other datum

1.2.5

counterbalance

dead weight added to the rear of the revolving structure of a crane to balance the forward moment of the weight of the jib and part of the hook load

1.2.6

dead load

any load of constant magnitude and position which acts permanently on the structure or member

1.2.7

derricking or luffing

angular movement of the crane jib in a vertical plane

1.2.8

fatigue

the tendency to fracture by means of a progressive crack, usually initiated by a stress concentration under repeated fluctuating stresses

1.2.9 Fluctuating stresses

The varying stresses due to the combined effect of dead and live loads are of two kinds:

1.2.9.1

pulsating stresses

stresses which change in magnitude but remain either tensile or compressive;

1.2.9.2

alternating stresses

stresses which change from tensile to compressive

1.2.10

gauge

the horizontal distance between the inside faces of the track rails (See *Rail centres*.)

1.2.11

height of lift

the vertical distance between the floor level or datum level, and the lowest point of the throat of the hook when the hook is in the highest working position

1.2.12

hoisting motion

the motion of lifting or lowering the load vertically

1.2.13

inertia forces

the forces produced by acceleration or retardation

1.2.14

jib length

the shortest distance between the fulcrum of the jib and the centre of the jib head pulley pin

1.2.15

level luffing

a luffing motion during which the load is automatically maintained at an approximately constant height

1.2.16

live load

any load which gives rise to variation of stress in a member. Such variation may be due to change of position or magnitude, or both, of an externally applied load, or to the movement of the crane structure itself. Wind loads are excluded from this definition

1.2.17

life expectancy

the probable life of the component under the specified service conditions

1.2.18

local bending

the bending induced in a member of a lattice frame when subject to loads between panel points, such bending to be considered at panel and intermediate points

1.2.19

luffing

see *Derricking*

1.2.20

maximum permissible working stress

numerically equal to the basic stress multiplied by the relevant duty factor *or* the permissible fatigue stress, whichever is the lesser, as defined in BS 2573-1

1.2.21

outreach

the horizontal distance from the centre line of the lifting hook to the nearest point on the crane chassis or base of an undercarriage or, in the case of a non-slewing crane, to the base

1.2.22

overhauling weight

a weight fitted to the hoisting rope above the lifting hook

1.2.23**radius**

the horizontal distances measured between the centre line of the hook and a vertical line projected through the centre of rotation

1.2.24**rail centres (span)**

the horizontal distance between the centres of the crane track rails (See Gauge.)

1.2.25**range of lift**

the vertical distance between the highest and the lowest working positions of the hook

1.2.26**safe working load**

the maximum load under specified conditions for which the crane may be used

1.2.27**slewing**

rotary motion of a crane jib or load about a vertical axis

1.2.28**stability of the crane**

where a load (or counterbalance) creates an overturning moment on a free standing crane, the stability is the resistance of the crane to overturning

NOTE There are two methods of expressing this condition.

a) *Percentage of tipping load.* The safe working load (SWL) appropriate to any given radius expressed as a percentage of the total load (TL) required at that radius to bring the crane to a condition of tipping:

$$\text{percentage of tipping load: } S \% = \frac{100\text{SWL}}{\text{TL}}$$

b) *Margin of stability.* The additional load (TL-SWL) expressed as a percentage of the safe working load (SWL) which is required to bring the crane to a condition of tipping, when it is handling the safe working load appropriate to any given radius:

$$\text{margin of stability: } SM \% = \frac{100(\text{TL} - \text{SWL})}{\text{SWL}}$$

1.2.29**stress concentration**

the localized increase of stress in any component due to a change of section or other cause

1.2.30**tail radius**

the maximum distance between the centre of rotation and the tail of the slewing superstructure

1.2.31**tower or mast**

that part of the crane structure which provides elevation and support for the jib mounting. The tower may or may not slew with the jib

1.2.32**travelling (long travel)**

horizontal movement of the whole crane relative to the ground

1.2.33**trolley**

the structure, mounted on wheels, which by its movement along the jib provides means of varying the radius

1.2.34**trolleying, or racking, or radial traversing**

motion applied to a carriage trolley travelling along a crane jib

1.2.35**wind load**

the forces produced by the velocity of the wind which is assumed to act horizontally

1.3 Information to be supplied with the enquiry or order

Information regarding the conditions under which the crane is to be used, together with the information required by Appendix A, should be supplied with the enquiry or order.

1.4 Information to be supplied by the manufacturer

The manufacturer shall supply with the tender the information required by Appendix B.

1.5 Service conditions

The crane shall be deemed to be under service conditions when it is operating without load or with a load up to the maximum safe working load. The loading shall include (in the case of outdoor cranes) the load imposed by the wind pressure as specified in BS 2573-1.

1.6 Classification (including duty)

This British Standard covers the design and construction of Classes 1 and 2 power-driven cranes of the tower type and the duty related to each of these classes is given in Table 1. For the purpose of computing permissible stresses, BS 2573-1 divides tower cranes into these same classes.

Table 1 — Classification and duties for power-driven tower cranes

Class	Assumed maximum number of hours in use per year (for design purposes)	Description of duty
1	1 000	Normal duty: for use on building sites
2	2 000	Medium duty: general use

1.7 Identification

For purposes of identification the crane shall bear the manufacturer's name, serial number, the year of manufacture and the "class" of crane (see 1.6).

If special materials, such as high tensile steel or aluminium alloy have been used in the structure, the crane shall bear a notice to this effect.

1.8 Materials

The materials and equipment used in the construction of the crane shall comply where applicable with the requirements specified in the appropriate British Standards.

Timber shall not be used for any load bearing member of the crane structure, but it may be used, for example, in the construction of the cabin.

1.9 Wind

The crane shall be designed in accordance with the requirements of BS 2573-1, taking into account the wind forces on the structure.

1.10 Stability

1.10.1 Under service conditions. The crane shall be designed to be stable when in any working position under the following two conditions.

- 1) The load on the hook is $1.6 \times$ the safe working load which produces the maximum overturning moment.
- 2) The load on the hook is $1.35 \times$ the safe working load which produces the maximum overturning moment, account being taken of the centrifugal effects due to slewing, the greater of the dynamic effects due to trolleying or travelling and the effect of service wind in accordance with BS 2573-1.

1.10.2 Under out-of-service conditions. The crane shall be designed to be stable when out of service while subjected to a wind pressure as specified in BS 2573-1, with the hook at the maximum working radius and the jib free to slew. It is permissible to increase the effective span of the supporting base by the use of outriggers or jacks, provided that they form a permanent part of the crane structure. Such outriggers or jacks shall be constructed so as to permit them to make satisfactory contact with a firm base and provide adequate support. The effect of fixing a crane to its rails shall not be taken into account when calculating stability, but the effect of devices, other than guy ropes, for securing the crane to fixed anchorages may be taken into account, provided that these are of sufficient strength and capacity to provide the required restraining forces, when calculating the stability under these conditions. A notice shall be fixed in the cab, and on the outside of the crane in a position clearly visible from the ground, giving instructions on what action shall be taken when the crane is left unattended, and special instructions on procedure when it is left in a position where the jib is prevented from slewing.

1.10.3 Backward stability. To ensure adequate backward stability, the centre of gravity of the crane shall be not further from the axis of rotation than 70 % of the minimum radial distance from the axis of rotation to the backward tipping fulcrum. For this purpose, the crane shall be assumed to be at rest without load and with jib or trolley at its minimum working radius.

1.10.4 Under erection conditions. During erection, dismantling or alteration to the configuration of self erecting cranes, the stability of the crane shall be maintained without external assistance such as guys, except where it is tied to a building for the purpose of normal operation.

1.10.5 General. The mass and position of the ballast required to ensure stability shall be clearly and permanently shown in a prominent position, and adequate provision shall be made for accommodating and, where necessary, securely fixing such ballast.

On rail-travelling cranes, the devices for anchoring the crane to the rails to prevent the crane travelling along the track when out of service shall not be taken into account when determining the stability of the crane in or out of service. Provision shall be made on a rail-travelling crane to prevent the stability being endangered in the event of breakage of an axle or wheel.

1.10.6 Stability of supports for cranes. It is the responsibility of the user to ensure that the crane cannot overturn under any of these conditions due to collapse of the ground under track, crawler track or fixed base, or due to structural failure of a base, or failure of the building supporting a climbing crane. The services of a competent engineer may be required in this connection.

1.10.7 Fixed and climbing cranes. The provisions of the above clauses should be taken into account when determining the dimension of the fixed base or plinth for a non-travelling crane and the stresses in those parts of the building (e.g. lift shaft) which will support the climbing crane. The services of a competent engineer are required in this connection. The manufacturer should supply full information about the horizontal and vertical loads and overturning moments induced by the crane.

1.11 Load and radius indication

The crane shall bear a legible and permanent inscription stating the length of the jib, the safe working loads, their appropriate radii and, where necessary, the reeving of ropes.

When change-speed gear is used on the hoisting motion, the safe working loads for each speed shall be similarly indicated.

For cranes of variable radius, clear indication of the permissible loads at various radii shall be given by means of an indicator in full view of the operator. Where provision is made for varying the length of the jib, the above requirements shall be satisfied in respect of each length of jib. (See also **D.3**.)

An automatic safe load indicator giving audible and visible warning to the operator and audible warning to persons in the vicinity shall be fitted on all cranes having a safe working load in excess of 1 t.

Such indicators shall comply with the appropriate current Statutory Regulations. (See Appendix C.)

2 Structural

2.1 Permissible stresses

The structure of the crane shall be designed to resist the horizontal and vertical bending stresses and direct stresses induced therein under all the conditions described in BS 2573-1 and including those described in **3.15** of this standard.

2.2 Jibs

On jibs with traversing trolleys, the boom carrying the trolley shall be designed to withstand the maximum axial stresses and bending stresses between panel points.

Failing a more accurate method which has been proved, the local bending stresses shall be calculated on the assumption of a beam freely supported at the ends and having a span three-quarters of the length between panel points. The bending moment at the panel points shall be assumed to be equal to that at the centre of the panel.

2.3 Joints

2.3.1 Strength of joint fastenings. Connections of members at an intersection shall develop at least the design loads and moments transmitted to them by the members. Due regard shall be given to the nature and distribution of stress over the cross section of the members when determining the distribution of the fastenings. All members shall, where possible, be so connected that the load is appropriately distributed over the cross section; otherwise, consideration shall be given to the distribution of stress through the material to those parts of the section not directly connected, and for this purpose the angle of distribution may be taken as 45° (see Figure 2).

The bending moment transmitted across a joint having bolt fasteners shall be considered as taken by the bolts in direct tension or shear, or a combination of both. Such loads shall be derived from the bolting pattern and the joint dimensions.

Where members are fastened by welding and are subjected to fluctuating stress, the requirements of BS 2573-1 shall be taken into consideration in choosing the type of joint, and its location, preparation and preheating, in order to reduce to a minimum the liability of the members to suffer from fatigue failure.

2.3.2 Welded joints

2.3.2.1 Welding processes. Welding processes shall comply with the British Standard specification appropriate to the welding process and the materials to be jointed.

2.3.2.2 Permissible stresses. Welding shall comply with the strength requirements, with allowance for fluctuating stresses, of BS 2573-1.

2.3.3 Bolted joints

2.3.3.1 General. The use of bolts shall satisfy the following conditions.

1) *Minimum spacing in stress-bearing members.* The distance between centres of bolts in shear shall not be less than 2.5 times the diameter of the bolt and shall not exceed sixteen times the thickness of the thinnest outside member or cover member in the joint. Where two lines of staggered bolts are used in the same plane, the maximum distance between the bolts on each line may be taken as 1.5 times those given above.

The distance between the centres of bolts used in shear and the sheared or hand flame-cut edge of a member shall not be less than 1.75 times the diameter of the bolt, and between the centre of the bolt and a rolled, machined or machine flame-cut edge shall be not less than 1.5 times the diameter of the bolt.

2) *Holes.* Holes shall be drilled accurately and all burrs removed before assembly.

Where bolts are used in shear, they should be fitted into reamed or accurately drilled holes whose diameter shall not exceed the diameter of the bolt by more than 0.4 mm (1/64 in).

The diameter of the holes for black bolts shall not exceed the diameter of the bolt by more than 1.6 mm (1/16 in).

3) *Black bolts.* Black bolts shall not be used in main members, in shear joints in stress-bearing members, or in joints subject to fatigue.

4) *Minimum number of bolts.* No joint shall depend for its integrity on only one bolt in tension, and joints shall be so designed that, should one bolt fail, the remaining bolt or bolts could carry the resulting loads without reaching their yield stress under any condition of loading, in or out of service.

5) *Barrel length.* Where bolts are used in shear, the plain barrel part of the bolt shall be sufficiently long to ensure adequate bearing area for the load.

6) *Fluctuating shear.* Bolts subjected to fluctuating shear loads must be tightened by controlled means.

2.3.3.2 Bolts tightened to proof load by controlled means. These bolts shall comply with BS 3139 or BS 4395 and shall be fitted in accordance with the recommendations of BS 3294 or BS 4604.

If, after tightening to proof load, a nut or bolt is slackened off for any reason, the bolt, nut and washer shall be discarded and not used again.

If friction-grip bolts are used in joints which require to be disconnected and reconnected during dismantling and erection, the crane shall bear a notice to the effect that such bolts must not be re-used after being slackened off.

2.3.3.3 Bolts which will be re-used after tightening by controlled means. Bolts which are to be re-used shall not be tightened beyond 70 % of the proof load given in BS 3139 or BS 4395 and such reduced proof load shall be used for design purposes. Where practicable the bolts shall be fitted in accordance with the recommendations of BS 3294 or BS 4604.

2.3.3.4 Bolts not tightened by controlled means. The stresses induced in bolts by external loading shall not exceed the permissible stresses derived from the basic stresses and methods given in BS 2573-1.

In the case of bolts having a yield strength beyond the limits of BS 2573-1 the following shall be applied.

1) For bolts not subjected to fluctuating loads the basic permissible stresses shall be taken as the following proportions of the yield stress of the bolt material:

basic permissible tensile stress: 40 %

basic permissible shear stress: 37.5 %

basic permissible bearing stress: 90 %

2) For bolts subjected to fluctuating external tensile loading, the difference between the stresses (corresponding to f_{max} and f_{min} .) thereby induced shall not be greater than 10 % of the ultimate tensile strength of the material and the mean stress shall not be greater than 15 % of the ultimate tensile strength of the material.

2.3.4 Riveted joints

2.3.4.1 Minimum spacing. The distance between adjacent rivets and the edges of members shall be in accordance with values specified in 2.3.3.1 1).

2.3.4.2 Holes. Holes shall be drilled accurately and all burrs removed before assembly. The diameter of the holes shall not exceed the nominal rivet shank diameter by more than 1.6 mm (1/16 in).

2.3.4.3 Permissible stresses. Rivets shall comply with the strength requirements, with allowance for reversal of stresses, of BS 2573-1.

2.4 Minimum sections

Plates, flat bars or angles used in the load bearing members of the structure shall be not less than 4.8 mm (3/16 in) thick. Similarly structural steel hollow sections which are sealed shall be not less than 2.3 mm (0.092 in) thick and, if unsealed, not less than 6.3 mm (¼ in) thick.

2.5 Structural sections

Steel sections and tubes shall comply with the appropriate British Standards.

2.6 Towers and masts

Diaphragm bracings or their equivalent shall be provided for stiffening purposes.

2.7 Means of access¹⁾

2.7.1 If the crane is fitted with a driver's cabin, safe means of access to it shall be provided by means of a permanent steel ladder attached to the structure.

2.7.2 Where practicable, vertical ladders exceeding 9.1 m (30 ft) in height shall be provided with intermediate resting places so that uninterrupted lengths of ladder do not exceed 9.1 m [see Construction (Working Places) Regulations 1966, Regulation 32/8].

¹⁾ See also CP 3010.

2.7.3 It is recommended that ladders shall be fitted with back hoops unless the ladders are inside a tower structure which effectively acts as a substitute for such hoops.

2.7.4 Safe access with adequate handholds and footholds shall be provided to all points requiring regular maintenance or inspection.

2.8 Rail centres

If a crane is adapted for travelling on rails, the carriage should preferably be designed to run on track at one of the following rail centres:

2.32 m 2.80 m 3.20 m 3.80 m 4.50 m 5.00 m 6.00 m
 7 ft 7 in 9 ft 2 in 10 ft 6 in 12 ft 6 in 14 ft 9 in 16 ft 5 in or 19 ft 8 in

3 Mechanical

3.1 Steel wire ropes

Ropes shall comply with BS 302.

NOTE Ropes having a higher tensile strength than that permitted by BS 302 are now available and may be fitted to tower cranes by agreement between purchaser and manufacturer.

The ratio of the minimum breaking load to the working load of a rope shall not be less than that given in Table 2.

For this purpose the working load on a rope shall be considered as a static load, i.e. omitting any dynamic or impact factor; this static load shall be increased by an increment to take into account the increased loads due to the following:

- 1) the bending of the rope over pulleys; and
- 2) pulley shaft bearing friction, making allowance for the ratio of pulley diameter to the pulley bearing diameter.

Tables enabling the rope tensions for various pulley systems to be calculated are given in Appendix F, together with a worked example showing how the “true” factor of safety may be obtained.

Table 2 — Ratios of minimum breaking load to working load

Class of crane	Hoisting ropes ropes	Trolleying ropes	Luffing ropes	Straight and standing ropes not reeved round pulleys
1	5	5	5	4
2	5	5	5	4

During erection, dismantling or out of service conditions the ratios given in the above table may be reduced by 20 %.

In cases where the load in the rope cannot be obtained readily from the load applied by the output end of a system, such as in the case of trolleying rope, erection and climbing ropes, the load shall be assumed to be equal to the pull on the rope drum when the prime mover is applying full load torque (a reduction of torque being made, where necessary, to allow for loss of efficiency in transmission between the prime mover and the winding drum). The ratio between the minimum breaking load of the rope and the load so obtained shall be not less than that given in Table 2.

3.2 Lifting hooks

3.2.1 Hooks shall be made from the materials specified in BS 2903 as applicable, and shall be heat treated in accordance with the requirements of the appropriate standard. When required, hooks shall comply with Regulation 36 of the Construction (Lifting Operations) Regulations 1961.

3.2.2 Swivelling hooks shall be mounted on rolling bearings.

3.2.3 The dimensions and testing requirements shall be not less than those specified in BS 2903.

3.3 Shackles

3.3.1 Shackles shall comply with BS 3032 or BS 3551.

3.3.2 Where used eccentrically, the shackles shall not be subjected to a load in excess of one-third of the normal proof load.

NOTE Slotted heads in countersunk screwed pins are not recommended for crane work.

3.4 Overhauling weight

When an overhauling weight is used on the rope it shall have a smooth bore and be bell-mouthed at the top and bottom and provision shall be made for the examination of the part of the rope passing through the weight.

The overhauling weight shall be designed so as to minimize the risk of it catching on obstructions.

3.5 Rope drum

3.5.1 General. Drums shall where possible accommodate in one layer the length of rope requisite for the range of lift. If the rope is wound on the drum in more than one layer the rope anchorage shall be located clear of the winding, preferably outside the flanges. Drums may be plain or grooved.

3.5.1.1 Adequate means shall be provided to prevent the rope inadvertently leaving the drum. If, solely for this purpose, the drum is flanged at both ends, the flanges shall project a distance not less than two rope diameters beyond the rope.

NOTE A spur or other wheel secured to the drum can form one of the flanges provided it is adequately guarded.

3.5.1.2 The inclination of the rope at the point of lead off from a drum shall not exceed 1 in 12 each side of a centre line which represents the true lead off.

3.5.1.3 If a rope leads off against the helix angle of the drum care shall be taken to prevent the rope rubbing against a neighbouring turn.

NOTE In extreme cases it may be necessary to increase the clearance between turns to comply with this requirement.

3.5.2 Drum diameters. The diameter of a plain drum, or a grooved drum measured at the bottom of the rope groove, shall be not less than 18 times the rope diameter for any construction of the rope.

For ropes used only for erection or dismantling; the minimum drum diameter shall be not less than 12 times the rope diameter.

3.5.3 Drum grooves. If a rope is grooved it shall comply with the following requirements.

3.5.3.1 The contour at the bottom of the groove shall be circular over a minimum angle of 120°.

3.5.3.2 The radius of the grooves shall be larger than the radius of the ropes by not less than the appropriate value given in Table 3.

Table 3 — Minimum groove radii for rope drums

Diameter of rope (<i>d</i>)	Minimum amount by which groove radius shall exceed rope radius
	mm
Up to and including 16 mm	0.8
Over 16 mm but less than 26 mm	1.2
26 mm up to and including 28 mm	1.6
Over 28 mm	2.4