IS 3177 (1999): Code of Practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Work Cranes [MED 14: Cranes, Lifting Chains and Related Equipment]

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IS 3177 : 1999
(Reaffirmed 2004)

भारतीय मानक

इस्पात कार्यक्रेन के अलावा शिरोपरि चलने वाली बिजली चालित क्रेन और गेन्ट्रीक्रेन की रीति संहिता

(दूसरा पुनरीक्षण)

Indian Standard

CODE OF PRACTICE FOR ELECTRIC OVERHEAD TRAVELLING CRANES AND GANTRY CRANES OTHER THAN STEEL WORK CRANES

(Second Revision)

Second Reprint SEPTEMBER 2008
(Including Amendment No. 1 & 2)

ICS 53.020.20

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

April 1999

Price Group 15

AMENDMENT NO. 1 DECEMBER 2000
TO
IS 3177 : 1999 CODE OF PRACTICE FOR ELECTRIC OVERHEAD TRAVELLING CRANES AND GANTRY CRANES OTHER THAN STEEL WORK CRANES

(Second Revision)

[Page 2, *clause* 3.2 (b)] — Substitute the following for the existing matter:

'b) Ambient temperature should be 0°C to 40°C and if the service conditions those beyond this, suitable derating factors shall be applied.'

(*Page* 3, *Fig.* 2) — Read dimension '*L* ' *for* dimension 'l'.

(*Page* 5, *Table* 1) — Substitute '1.4' *for* '1.50' in col 2 against M7.

(*Page* 5, *clause* 7.3.1) — Substitute '7.2' *for* '8.2' under R_{hi}.

(*Page* 9, *clause* 8.1.2) — Substitute the following for the existing matter:

'For loads up to and including 50 t, Shank type plain hooks be used unless otherwise specified by the purchaser. For loads of 50 t and over, hooks of Rams horn type or triangular lifting eyes are to be preferred where there is a chance of fouling of hook and the risk of displacement of load during hoisting and for lowering 'C' type hook shall be used. Hook with hook latch is to be provided with closing fingers to prevent slippage of load. However an option can be given to the purchaser on whether hook is to be provided with closing fingers or hook latch. In this case the hinge lug for the closing finger shall be forged with the hook. The finger shall be capable of taking load equal to 1.5 times of the weight of hook block without distortion in accordance with IS 13870 (Part 1).'

(*Page* 10, *clause* 8.3.2) — Substitute the following for Z_p:

'Z_p = minimum practical co-efficient of utilization. For normal condition Zp shall be taken equal to 6 for M7 and M8, Z_p = 4 for M1 to M6.'

(*Page* 11, *clause* 8.4.6 *explanation for 'd'*) — Substitute 'diameter of the rope, in mm' for the existing matter.

(*Page* 11, *clause* 8.5.2, *first paragraph*) — Substitute '8.4.6' *for* '7.4.6'.

1—51 BIS/ND/2008

(*Page* 13, *clause* **8.6.6**) — Delete $D = \frac{1.5\,W}{a}$ or, and

substitute the following for the existing formula:

$$D = \frac{P_{mean} \times C_{df} \times C_{sf}}{1.5\,a \times C_{bh} \times C_{ap}}$$

where

D = tread diameter of the wheel in mm;

P_{mean} = mean wheel load in newtons;

A = useful width of rail;

C_{df} = duty factor for the appropriate mechanism class as defined in **7.4.3;**

C_{bh} = hardness factor for the wheel material. For values, refer Table 9. Here wheel hardness B_{hw} as calculated in **8.6.3** shall be used even if wheel rim if hardened more for longer wheel life;

C_{sf} = safety factor depending on the material used as defined in **7.4.3**; and

C_{sp} = co-efficient depending on the speed of rotation of the wheel as defined in Table 10.

(*Page* 16, *clause* **8.7.1**, *second paragraph*) — Delete 'steel' from the first line.

(*Page* 17, *clause* **8.8.2**) — Substitute 'or' *for* 'of' in first line of sentence.

(*Page* 17, *clause* **8.8.3**) — Substitute the following for third paragraph:

'The gearbox mounting shall be machine cut, seated and positively located on machined surface.'

(*Page* 21, *Table* 12) — Substitute '240' *for* '60' in column 3 against 'ac Magnets'.

(*Page* 25, *clause* **15.2.2**, *first paragraph, third sentence*) — Substitute 'or' *for* 'of'.

1—51 BIS/ND/2008

(*Page* 25, *clause* 15.2.3) — Substitute the following for the first sentence:

'The provision of overload protection shall be with adjustable inverse time log overload release.'

(*Page* 26, *clause* 15.2.4, *first paragraph*) — Delete the last sentence.

[*Page* 31, *clause* 20.2 (a) *and* (b)] — Substitute 'Class' *for* 'sizes'.

(*Page* 32, *clause* 22.3) — Substitute '20' *for* '19'.

(*Page* 34, *Table* 17) — Substitute 'without cover' *for* 'with cover' in column 2 under IP 54.

[*Page* 43, *clause* 28.3 (a), load test] — Substitute '50' *for* '5'.

[*Page* 43, *clause* 28.3 (b), load test] — Substitute '100' *for* '125.'.

Add '28.3 *Load Test* (c) Load the hoist motion with 125 percent of rated capacity, lift the load for 1M height and then lower the load'.

(*Page* 52, *clause* C-1) — Substitute 'C_{df}' *for* 'C_{dr}'.

(*Pages* 52 *and* 53, *clause* C-1) — In factor C_{df}, substitute '7.4.3' *for* '6.4.3'.

(*Page* 53, *Table* 20B) — Substitute the following table for the existing:

Table 20B Recommended Cyclic Duration Factor and Starting Class
(Clause C-1)

Mechanism Class	Duty Cycle Number of Cyclic Class (C) Cycles/hour, percent	Recommended Cyclic Duration Factor percent	Starting Class (C) Equivalent Starts/hour
M1	Up to 5 cycles 25	25	90
M2	Up to 5 cycles 25	25	90
M3	10 to 15 cycles 40	25	150
M4	16 to 20 cycles 40	25	150
M5	21 to 30 cycles 60	25/40	150/300
M6	31to 40 cycles 60	40	300
M7	41 to 50 cycles 100	60	300
M8	51 to 60 cycles 100	60	300/600

Amend No. 1 to IS 3177 : 1999

(*Pages* 53 *and* 54, *Annex* C, *clause* C-2.2) — For explanation of *T*, delete last two lines after the explanation and substitute Table 21B with the following:

Table 21B Values of Service Factors

(*Clause* C-2.2)

Bridge Service Factor		Trolley Service Factor
Without Plugging	With Plugging	
0.95	1.00	1.06

(*Page* 54, *clause* C-2.2) — Substitute '7.4.3' *for* '6.4.3' (under C_{df}) and '7.3.1' *for* '6.3.1' (under *R*w1).

(MED 14)

AMENDMENT NO. 2 JULY 2003
TO
IS 3177 : 1999 CODE OF PRACTICE FOR ELECTRIC OVERHEAD TRAVELLING CRANES AND GANTRY CRANES OTHER THAN STEEL WORK CRANES

(Second Revision)

[*Page* 10, *clause* **8.3.2** (*see also Amendment No.* 1)] — Substitute the following for Z_p:

'Z_p = minimum practical coefficient of utilization. For normal condition Z_p shall be taken equal to 3.5 for M1 to M8 other than hot mill duty cranes. Z_p shall be taken equal to 5 for hot mill duty cranes.'

[*Page* 13, *clause* **8.6.6** (*see also Amendment No.* 1)] — Substitute the following for the existing formula:

$$D = \frac{P_{mean} \times C_{df} \times C_{sf}}{1.5\, a \times C_{bh} \times C_{sp}}$$

(*Page* 54, *Annex* C) — Substitute explanation for notation 'N' for existing:

'N = mechanical efficiency of gearing. For spur and helical gears, efficiency to be taken as 0.95 per reduction. For hardened and ground gears, efficiency to be taken as 0.985 per reduction.'

(MED 14)

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cranes, Lifting Chains and Related Equipments Sectional Committee had been approved by the Heavy Mechanical Engineering Division Council.

This standard covers mechanical and electrical aspects related to design, manufacture, erection and testing of electric overhead travelling cranes and gantry cranes used in hazardous areas like Gas Group 2c. Electrical motors and electric thruster unit for brakes, limit switches, Pendant push button station and panels shall be of flameproof suitable for Gas (Group 2c).

An attempt is made here to include provisions:

a) to bring this standard in line with the International Standards,

b) to keep higher factor of safety for hoisting mechanisms compared to travelling mechanisms which may reduce cost of cranes without sacrificing safety, and

c) to help standardization, as far as possible, relating requirements for components to basic duty factor for class of mechanisms.

While preparing this standard assistance has been derived from various Indian, British, DIN, FEM and ISO standards to bring this standard in line with the International Standards.

As followed in the International Standards, structural provisions for cabin, walkways and means of access are not included in this standard. It is proposed that the same should be added in IS 807. In line with this standard and new classifications now adopted, IS 807 should be modified. Provisions in IS 807 for allowable stresses, deflection criteria, wheel base to span ratio and tolerances on spans, wheel alignment, etc, be modified to bring the standard in line with International Standard.

The new classification of cranes now coming into effect and the classification presently in use can approximately be compared as follows:

Old Equivalent	*New Classification*
I	M3
II	M5
III	M7
IV	M8

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CODE OF PRACTICE FOR ELECTRIC OVERHEAD TRAVELLING CRANES AND GANTRY CRANES OTHER THAN STEEL WORK CRANES

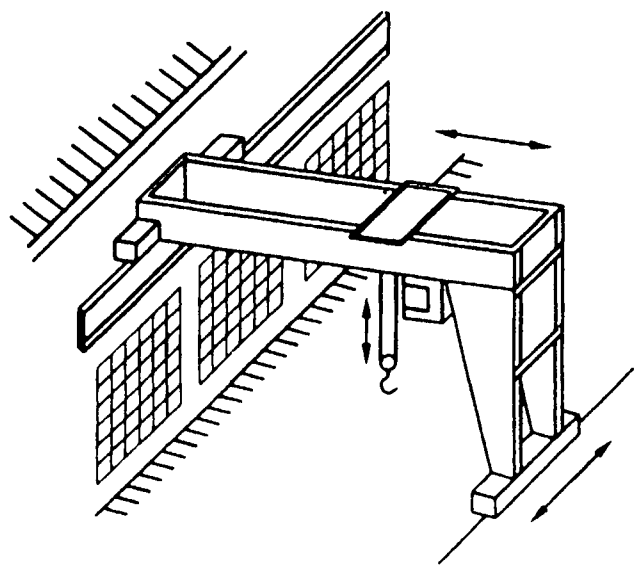
(Second Revision)

1 SCOPE

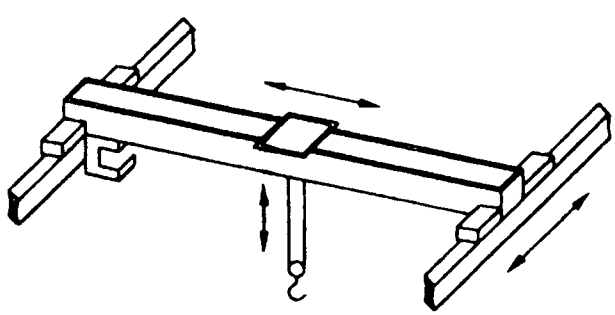
This code covers mechanical, electrical, inspection and testing requirements relating to the design, manufacturing and erection of electric overhead travelling cranes, portal and semi - portal cranes, single girder, double girder or mono-box type (*see* Fig. 1). It does not cover steel work cranes which are covered in IS 4137 : 1985 and new classification for the crane as a whole, which has been defined as from No. A1, A2, ... A8 and crane mechanism has been defined as from Nos. M1, M2, ... M8 according to IS 13834 (Part 1) : 1994.

2 REFERENCES

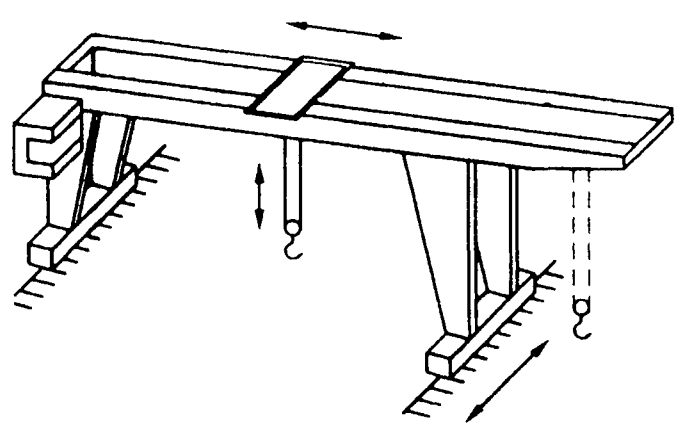
2.1 The Indian Standards listed in Annex F are necessary adjuncts to this standard.



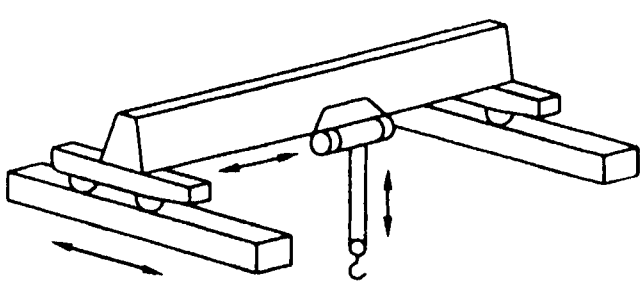
1C Semi Goliath Crane



1A Top Running Crane (Double Girder)

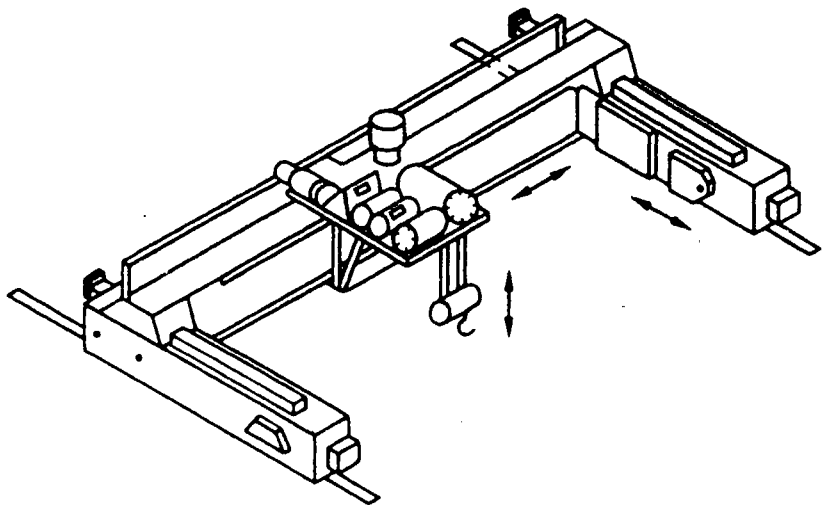


1D Goliath Crane (with Cantilevered Extension)



1B Top Running Crane (Single Girder)

FIG. 1 TYPICAL CRANE TYPES (*Continued*)



1E Offset Crab Crane

FIG. 1 TYPICAL CRANE TYPES

SECTION 1 GENERAL

3 TERMINOLOGY

3.1 General

For the purpose of this standard the definitions given in IS 13473 (Part 1) and following text shall apply. If there are common terms, the definitions given in this standard shall prevail.

3.2 Normal Service Condition

Normal service condition shall satisfy the following conditions.

a) Indoor and outdoor applications should with normal air of normal humidity and free from contamination.

b) Ambient temperature should be between 0°C and 40°C and if the service conditions those beyond this, suitable derating factors shall be applied.

c) Altitude should not exceeding 1 000 m above mean sea level.

4 TECHNICAL INFORMATION TO BE PROVIDED

4.1 Information to be Provided Before Finalizing the Order

4.1.1 *Information to be Provided by the Purchaser*

All the necessary information regarding the conditions under which the crane is to be used, together with the particulars laid down in Annex A shall be supplied with the enquiry or order by the purchaser to enable the crane manufacturer to offer the most suitable crane and equipment to satisfy the duty requirements and service conditions. The enquiry shall also be accompanied with a clearance diagram.

4.1.2 *Information to be Provided by the Manufacturer*

The manufacturer shall supply with the tender along with the requisite information like regarding the construction of the crane according to the particulars laid down in Annex B unless agreed otherwise by the purchaser.

4.2 Information to be Provided Prior to Installation and Commissioning of the Crane

The manufacturer shall provide the following information while commissioning of the crane:

a) General arrangement drawings showing all leading dimensions and installation details which were given in Fig. 2A and 2B respectively;

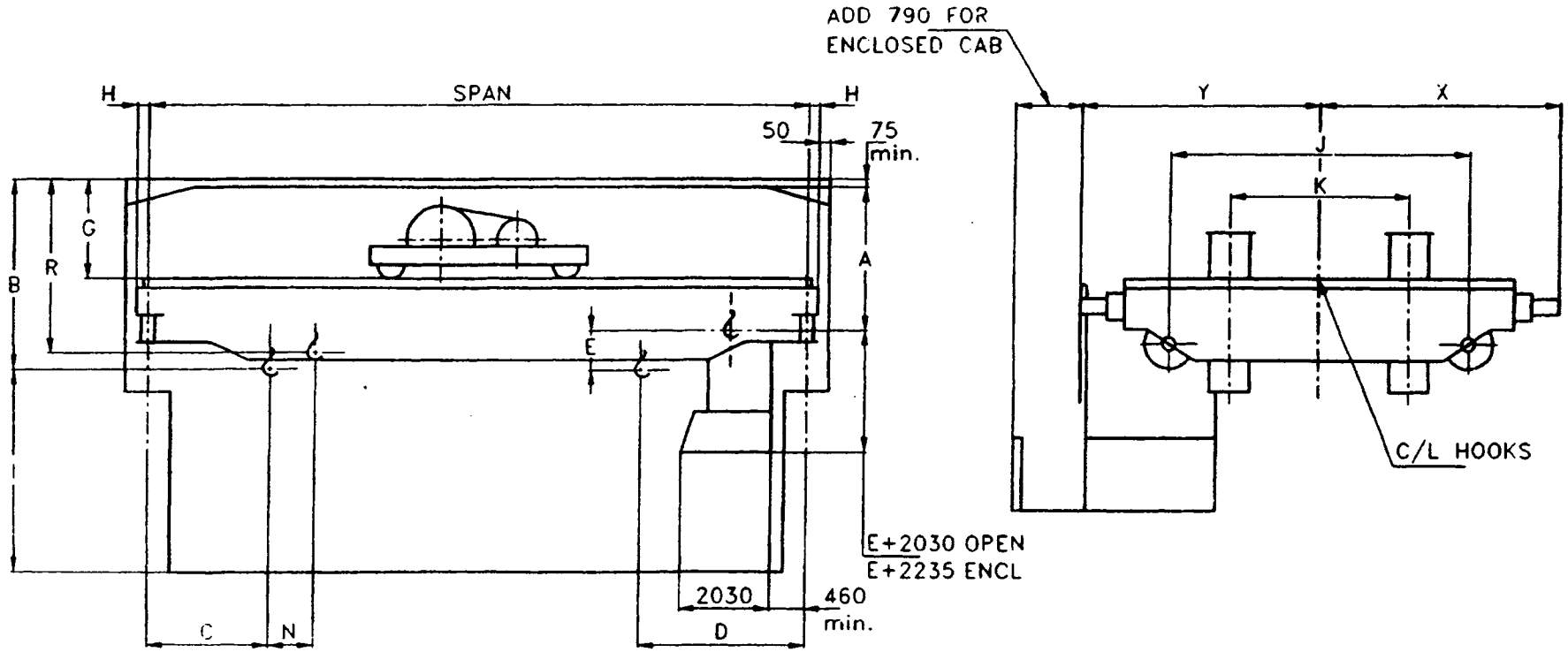
b) Circuit and wiring diagram;

c) Operating and maintenance instructions;

d) Recommended spare parts list;

e) Test certificate;

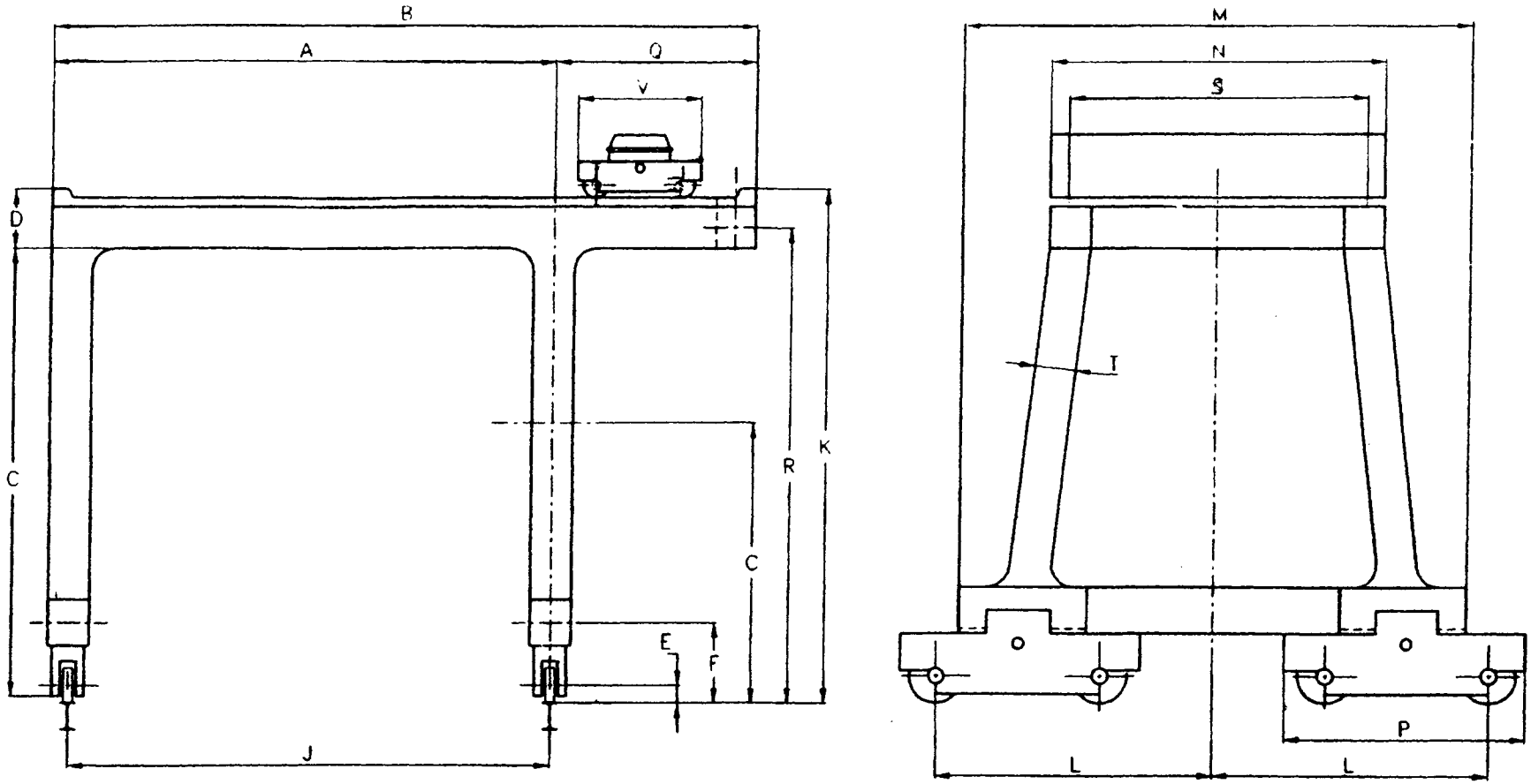
f) Details of all brought outs such as motors.



RATED LOAD	SPAN	A	B	C	D	E	G	H	J	K	L	X	Y

2A E. O. T. Clearance Diagram

FIG. 2 DIMENSIONS FOR E. O. T. CLEARANCE AND GANTRY CRANE CLEARANCE DIAGRAM (*Continued*)



RATED LOAD	SPAN	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U

2B Gantry Crane Clearance Diagram

FIG. 2 DIMENSIONS FOR E. O. T. CLEARANCE AND GANTRY CRANE CLEARANCE DIAGRAM

gear box, brakes, etc, along with their manufacturer's name, model number, address, etc; and

g) Should also provide full details of the wire rope used such as construction, length, grade and manufacturer's name, etc.

5 IDENTIFICATION AND LOAD INDICATION

5.1 Both sides of the crane shall bear one or more plaques along with permanent inscription on which the following shall be inscribed:

a) Manufacturer's name and trade-mark,

b) The safe working loads of each independent hoist of the crane, and

c) Purchaser's crane code number (if required by the purchaser).

These plaques should be readily legible from the ground floor level or operating level and shall be accessible for maintenance.

5.2 A small plaque shall be located in a prominent position in the cab or at the approachable portion of the crane bearing the following inscription:

a) Manufacturer's name and trade- mark,

b) Manufacturer's serial number,

c) Year of manufacture, and

d) Safe working load.

6 CLASSIFICATION

The classification of the crane as a whole and of each mechanism shall be based on the information provided by the purchaser and shall be determined in accordance with IS 13834 (Part 1) and IS 13834 (Part 5) respectively.

NOTES

1 The classification of the individual motions of a crane may not necessarily be the same as those of crane structure. The classification of one motion of a crane may differ from that of another motion of the same crane.

2 In the case where a crane mechanism is required to perform a duty that falls beyond the Group Classification M8, either the mechanism shall be designed for higher hook load or other parameters shall be changed so that it satisfies requirement for the Group Classification M8.

SECTION 2 MECHANICAL

7 DESIGN OF CRANE MECHANISM

7.1 General

The design of the component parts of the mechanism relating to each crane motion shall be included with due allowance for the effects of the duty which the mechanism will perform in service. The design of the component parts shall be in accordance with the provisions given in this section.

7.2 Impact Factor

The impact factor applied to the motion of the hook in a vertical direction covers inertia forces including shock. In calculating the live loads in the components of the mechanism, the rated hook load shall be multiplied by the impact factor, given in Table 1 for various classes of mechanism which were given below :

Table 1 Impact Factor for Structural Design

Group Classification of the Mechanism	Impact Factor
M1	1.06
M2	1.12
M3	1.18
M4	1.25
M5	1.32
M6	1.40
M7	1.50
M8	1.50

7.3 Loadings to be Considered in the Design of Mechanisms

7.3.1 *Loads*

The following loadings shall be taken into account when designing a mechanism and its components:

R_d = loads due to the dead weight of the mechanism or component and dead weight of those parts of the crane acting on the mechanism or the component under consideration.

R_h = loads due to the weight of the hook load with reference to Fig. 3 and also it is defined as SWL of the hook.

R_{hi} = loads due to the weight of the hook load increased by the impact factor given in **8.2**.

R_m = dynamic loading arising from the acceleration or braking of the motion and from skewing interaction between the crane and track. These loads include those loads

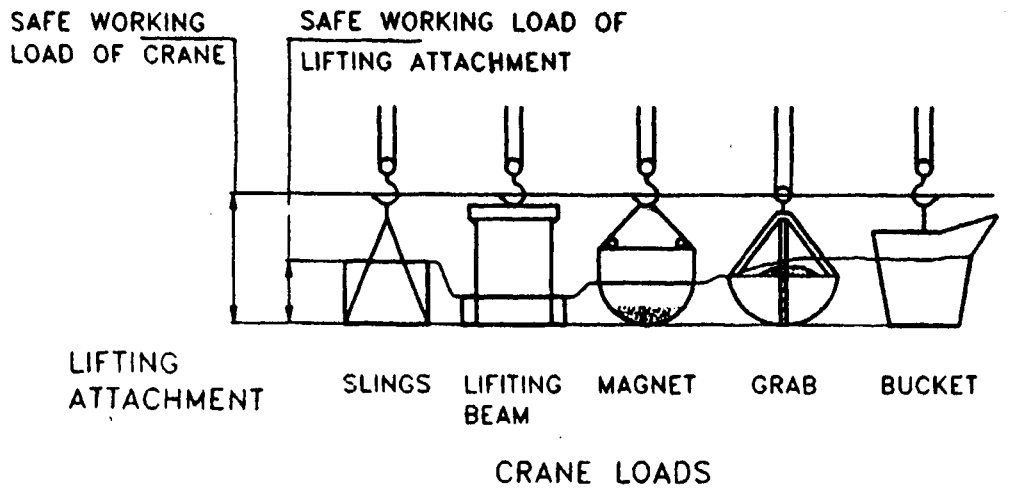


FIG. 3 ILLUSTRATION OF TYPICAL ATTACHMENTS IN RELATION TO SAFE WORKING LOAD

due to the below said reasons:

a) inertia of the mechanism, associated crane parts and hook load,

b) its prime mover and brakes, and

c) concurrent operation of other motions, etc, as applicable.

R_f = loads arising from frictional forces.

R_{w1} = loads due to the service wind acting horizontally in any direction where applicable according to IS 875 (Part 3).

R_{w2} = loads due to the out of service wind acting horizontally in any direction where applicable according to IS 875 (Part 3).

R_d = loads due to collision with end buffers.

7.3.2 *Loading Condition and Load Combinations*

Each mechanism of the crane shall be designed to operate satisfactorily under the most unfavourable combination of loadings that can occur under different conditions and that could also actually occur in practice.

Case I Normal service without wind where crane capacity equal to R_h

a) *Vertical motion* : hoisting or lowering

1) $R_d + R_h + R_m + R_f$

2) $R_d + R_h$

b) *Horizontal motion* : traverse or travel

$$R_d + R_h + R_m + R_f$$

Case II Normal service with wind

a) *Vertical motion* : hoisting or lowering

1) $R_d + R_h + R_m + R_f + R_{w1}$

2) $R_d + R_h + R_{w1}$

b) *Horizontal motion* : traverse or travel

$$R_d + R_h + R_m + R_f + R_{w1}$$

Case III Crane out of service

a) *Vertical motion* : hoisting or lowering not applicable.

b) *Horizontal motion* : traverse or travel

$$R_d + R_{w2}$$

Case IV Exceptional loading condition

The combination of loads to be considered for this case of loading will depend upon the type of crane, application and the crane motion. Account shall be taken of any loading condition that are known to apply but which are not covered under the other three cases of loading. A few cases of exceptional loading are as follows:

a) Loads due to collision of cranes with each other or with end stoppers that is buffer loads.

b) Loads due to testing of cranes.

c) Erection loads.

d) Loads due to the maximum load that the motor can actually transmit to the mechanism while starting, stalling or due to higher actual power.

7.4 Design Procedure

7.4.1 *General*

Mechanism components shall be proportioned by checking that they have adequate safety against becoming unserviceable as a result of a single combination of extreme loading conditions causing fracture, bending or other type of failures. They shall also be checked whenever appropriate against fatigue, deflection or over heating. In this connection, consideration shall be given to the consequences of failure. For example, failure in hoisting mechanism component is usually more dangerous occurrences than failure of a horizontal motion mechanism.

7.4.2 *Basis of Design*

Mechanism components are checked depending on the ultimate strength by verifying that the calculated stress does not exceed a permissible stress dependent on the breaking strength of the material used.

7.4.3 *Permissible Stress*

Mechanism component shall be checked for strength under Case I, II, III and IV loading conditions and load combinations specified in 7.3.2. The value of the permissible stress F_a is given by following formula where unit of stress was defined as N/mm²:

$$F_a = \frac{F_{ult}}{C_{df} \times C_{bf} \times C_{sf}}$$

where

F_{ult} = ultimate tensile strength of the material.

C_{df} = duty factor for the appropriate mechanism class. For the values refer Table 2.

C_{bf} = basic stress factor corresponding to each case of loading. For the values refer Table 3.

C_{sf} = safety factor depending on the material used. For the values refer Table 4.

7.4.4 *Relation between Calculated and Permissible Stresses*

According to the type of loading to be considered the following relations shall be verified:

a) Pure tension $1.25 f_t \leq F_a$

b) Pure compression $f_c \leq F_a$

Table 2 Values of Co-efficient, C_{df}
(*Clause* 7.4.3)

Group Classification of Mechanism	For Mechanism Used for Horizontal Motion	For Mechanism Used for Vertical Motion	For Mechanism Used for Vertical Motion with People or While Handling Dangerous for Example, Molten Metals, Highly Radio-Active or Corrossive Products
M1	1.00	1.18	1.32
M2	1.06	1.25	1.40
M3	1.12	1.32	1.50
M4	1.18	1.40	1.60
M5	1.25	1.50	1.70
M6	1.32	1.60	1.80
M7	1.40	1.60	1.90
M8	1.50	1.70	2.00

Table 3 Values of Co-efficient, C_{bf}
(*Clause* 7.4.3)

Case of Loading	I	II	III and IV
C_{bf}	3.15	2.5	2.0

Table 4 Values of Co-efficient, C_{sf}
(*Clause* 7.4.3)

For ordinary grey cast iron or for cast or forged components where blow holes or internal cracks can not be detected.	1.25
For mild steel Fe 310 and Fe 410	1.12
For other materials Fe 44 and Fe 57, etc.	1.00

c) Pure bending either compression or tension

$$f_{bt} \text{ or } f_{bc} \leq F_a$$

d) Combined bending and tension

$$1.25f_t + f_{bt} \le F_a$$

e) Combined bending and compression

$$f_c + f_{bc} \le F_a$$

f) Pure shear $\sqrt{3}f_s \le f_a$

g) Combined bending, tension and shear

$$\sqrt{[(1.25f_t + f_{bt})^2 + 3f^2]} \le F_a$$

h) Combined bending, compression and shear

$$\sqrt{[(f_c + f_{bc})^2 + 3f_s^2]} \le F_a$$

where

f_t = calculated axial tensile stress,

f_c = calculated axial compressive stress,

f_{bt} = calculated maximum tensile stress due to bending about both principal axes,

f_{bc} = calculated maximum compressive stress due to bending about both principal axes, and

f_s = calculated shear stress.

7.4.5 *Checking for Fatigue*

7.4.5.1 *General*

Where it is necessary to check a component for fatigue, recognized techniques available for calculation of fatigue properties shall be used. The choice of the methods used shall be left to the manufacturer, however he shall specify the origin of the methods to be adopted if asked by the customer.

7.4.5.2 *Loading condition*

Case I of loading condition as specified in 7.3.2 shall be used as the basis for all fatigue checks.

7.4.5.3 *Factors affecting fatigue strength*

For any component, the magnitude of the fatigue reference stress depends upon the following factors:

a) the total number of stress cycles during the service life of the component '*n*',

b) the type of stress cycles (that is, degree of stress fluctuation),

c) the quality of the material,

d) the size of the component,

e) the surface finish of the component,

f) the configuration of the individual details under consideration,

g) miscellaneous effects such as the effects of corrosion, residual stress, electrolytic plating, metal spraying, etc, where under certain conditions reduce the permissible fatigue stress. Annex B gives a method for calculating the fatigue reference stress (p_{fr}) which takes account from the factor (a) to (g) above and includes allowance giving a 90 percent probability of survival.

NOTE - A check for fatigue need not be made in the cases, where experience shows that the ultimate strength check as per 7.4.3 is sufficient

7.4.5.4 *Stresses*

The following characteristics shall be determined for each type of fluctuating stress, for example tension, compression, bending or shear; occurring during an appropriate stress cycle in the component detail having regard to the loading that it will experience:

f_{Max}, f_{Min} = extreme values of stress occurring in the stress cycle

f_{Min} = considered as negative if it is of opposite sense to f_{Max}

p_{fb} = permissible fatigue stress in bending

p_{fs} = permissible fatigue stress in shear

p_{fr} = fatigue reference stress at which a component detail has a 90 percent probability of survival

$f_{a\,Max}, f_{a\,Min}$ = extreme values of axial tensile stress

$f_{b\,Max}, f_{b\,Min}$ = extreme values of stress in bending

$f_{s\,Max}, f_{s\,Min}$ = extreme values of torsional shear stress.

$\frac{f_{Min}}{f_{Max}}$ = maximum degree of stress fluctuation.

7.4.5.5 *Permissible fatigue stress*

The permissible fatigue stress '*Pf*' for each type of stress, for example tension, bending or shear is given by:

$P_f = 0.8\ P_g$ for hoisting mechanisms
$= 0.85\ P_g$ for all other mechanisms.

Where the component detail is subjected to a single type of fluctuating stress that is f_{Max} shall not exceed P_f the permissible fatigue stress.

The stress combination occurring most frequently in practice in a component detail is that of bending and torsion. The details subjected to this combination shall be designed so that:

$$\left(\frac{f_{b\,Max}}{P_{fb}}\right)^2 + \left(\frac{f_{s\,Max}}{P_{fs}}\right)^2 < 1.0$$

7.4.6 *Checking for Crippling*

Component subjected to crippling that is overall flexural buckling due to axial compression shall be checked so that the calculated stress does not exceed a limit stress determined as a function of critical stress above which there is a risk of crippling occurring. For this check co-efficient C_{dr} as given in Table 2 shall be taken into account.

7.4.7 *Checking for Wear*

In the case of parts subjected to wear, the specific physical quantities such as surface pressure or the circumferential velocity must be determined. The figures must be such that on the basis of present experience they will not lead to excessive wear.

7.4.8 *Means of Access*

7.4.8.1 *General requirements*

In front of the panel the working place shall be minimum of 500 mm or width of the door of the panel or whichever is more. Safe means of access shall be provided to the driver's cabin and to every place where any person engaged on the inspection, repair and lubrication of the crane will be called upon to work; adequate handholds and footholds being provided where necessary.

7.4.8.2 *Platforms*

Every platform shall be securely fenced with double tiered guard rails having a minimum height 1.1 m and toe boards, unless parts of the crane structure provided safely. The platform normal width with only check plates shall be of sufficient to enable normal maintenance work to be carried out safely. On bridge platform, which shall be not less than 0.75 m in normal width, the fencing shall extend along the full length of the outer edge.

Guard rails on the crab side of the bridge platform may be provided, if required.

7.4.8.3 *Ladders*

Side of ladders normal width with only check plates preferably from platform to the cabin shall extend to a reasonable distance above the platforms or other reliable handholds shall be provided. Ladders shall if possible, slope forward. Vertical ladders exceeding 3 m in length shall be provided with back safety guards.

8 SELECTION OF COMPONENTS

All components shall be selected or designed under the loading conditions specified in 7.3.

8.1 Lifting Hooks

8.1.1 *General*

Lifting hooks shall comply with IS 3815 and IS 5749.

8.1.2 *Types*

For loads up to and including 50 t, Shank type plain hooks be used unless otherwise specified by the purchaser. For loads of 50 t and over, hooks of Ramshorn type or triangular lifting eyes are to be preferred.

Where there is a chance of fouling of hook, hook with hook latch is to be provided with closing fingers to prevent slippage of load and the risk of displacement of load during hoisting and for lowering operation 'C' type hook shall be used. However an option can be given to the purchaser on whether hook is to be provided with closing fingers or hook latch. In this case the hinge lug for the closing finger shall be forged with the hook. The finger shall be capable of taking load equal to 1.5 times of the weight of hook block without distortion in accordance with IS 13870 (Part 1).

8.1.3 *Mounting*

Swiveling hooks shall be mounted on thrust bearings. A protective skirt shall be provided to enclose the bearings. The thrust bearings shall be provided with facilities for lubrication, however facilities for lubricating need not necessary in case of self lubricated nylon bearing pads. If required, a locking device shall be fitted to prevent rotation of hook.

8.2 Shafts

8.2.1 *Material*

All shafts shall be made of steel. Shafts and axles shall have ample strength, rigidity and adequate bearing surfaces. Suitable surface finish for stressed portions of the shafts shall be selected having regard to size, stress levels, severity of stress raising features

and the needs of bearings, seals, etc. Adequate allowances shall be made for the effective losses in section due to key-ways, splines, etc. Large changes in the section shall be avoided wherever possible. Shafts, if shouldered, shall be provided with fillets of as large a radius as possible and/or be suitably tapered. All shafts shall be supported on minimum two bearings. Splines and serrations shall comply with relevant Indian Standards.

The travel driving shaft or shafts shall be supported on self aligning bearings at a distance so that the deflection due to the self weight of the shaft is between 0.03 to 0.05 percent of unsupported length of the shaft. Angular deflection of the line shaft at torque corresponding to 1.5 times the motor torque during acceleration period shall not be more than 0.25° per metre of shaft length. The drive for the line shaft shall be mounted as close as practicable to the centre of the span. Each part of the drive shaft shall be designed to transmit maximum torque due to the most unfavourable load position.

8.3 Wire Rope

8.3.1 *General*

Hoisting rope, unless otherwise specified or agreed by the purchaser, shall conform to IS 2266. Steel core ropes with construction and tensile designation of wires as '1960' shall be used for the applications under water or in the corrosive atmosphere or while handling hot metal. Ropes working under water and in corrosive atmosphere should be galvanized.

8.3.2 *Selection Procedure*

The selection procedure adopted here assumes that the ropes are lubricated correctly, that the winding diameters on the pulleys and drum are selected in correspondence with this standard and that the ropes are properly maintained, inspected and periodically replaced. The selection of rope diameter shall be related to the following:

a) group classification of the mechanism,

b) the rope receiving system employed and its efficiency,

c) rope inclination at the upper extreme position of the hook, if the rope inclination with respect to hoist axis exceeds 22.5°

The minimum breaking load F_0 of the rope intended for a particular duty shall be determined from the formula given below, however impact factor should not be considered while calculating the rope tension.

where

S = maximum rope tension considering inclination of the rope in the uppermost position.

Z_p = minimum practical co-efficient of utilization. For normal condition Z_p shall be taken equal to 6.0.

C_{df} = duty factor for hoisting as defined in 7.4.3.

8.3.3 *Examination, Maintenance and Discard of Wire Ropes*

For the examination, maintenance and discard criteria of wire ropes, guidelines given in IS 3973 shall be adopted.

8.4 Rope Drum

8.4.1 *General*

Drums shall be designed for single layer of ropes only and shall be designed with multilayer guided rope when agreed to between the manufacturer and the purchaser.

8.4.2 *Length of the Drum*

The drum shall be of such length that each lead of wire rope has a minimum of two full turns on the drum when hook is at its lowest position not taking into consideration the turns covered by the wire rope anchorage and one spare groove for each lead of the wire rope on the drum when hook is at its highest position.

In the case where the drum flanges are not provided, a free length not less than 4 times to the diameter of the wire rope or 100 mm dia whichever is more is to be provided beyond the last groove center line at the anchorage point.

8.4.3 *Flanges*

The drums shall be flanged at one or both ends in the following conditions such as:

a) For single flange drum, at the end where wire rope is released.

b) For drums having handed grooves at both ends if wire ropes are released from the end of drums.

c) For multi-layer wire ropes at both ends.

d) If required by the purchaser.

Where provided, the flanges shall project above the wire rope to a distance not less than 2 times of the wire rope diameter.

8.4.4 *Lead Angle*

The lead angle of the rope shall not exceed 5° on either side of helix angle of the groove in the drum.

8.4.5 *Grooving of the Drum*

Rope drums shall have machined grooves and the contour at the bottom of the grooves shall be circular over a minimum angle of 120°.

Grooving shall be finished smooth and shall be free from surface defects likely to injure the wire rope. The edges between the grooves shall be rounded. The radius of the groove shall be between 0.53 to 0.59 times the diameter of the wire rope rounded off upwards to the nearest 0.5 mm. The depth of the groove shall not be less than 0.3 times the diameter of the wire ropes for drum with single layer of the wire rope and 0.2 times the diameter of the wire rope for multiple layers of wire rope on the drum. The pitch of the grooves of the drum shall not be less than 1.08 times the diameter of the wire rope for the drum with single layer of the wire rope and 1.05 times the diameter of the wire rope for multiple layers of the wire rope on the drum.

8.4.6 *Diameter of the Drum*

The diameter of the drums at the bottom of the groove shall be standardized to sizes 200, 250, 315, 400, 500, 630, 710, 800, 900, 1 000 and 1 250 mm.

The diameter of the drum measured at the bottom of the groove shall be not less than the value calculated as follows:

$$D_d = 12 \times d \times C_{df} \times C_{rc}$$

where

D_d = diameter of the drum measured at the bottom of the groove, in mm;

d = calculated diameter of the rope, in mm;

C_{df} = duty factor for hoisting for the appropriate mechanism class as defined in **7.4.3**; and

C_{rc} = factor dependent on the construction of wire rope.

For wire rope construction:

6 × 36 or 6 × 37	C_{rc} = 1.0,
6 × 24	C_{rc} = 1.12,
6 × 19	C_{rc} = 1.25.

8.4.7 *Material for the Drum*

Drums shall be made of seamless pipe as per ASTM A 106 GR A and B, cast iron of minimum Grade 25, cast steel, rolled steel of welded construction and in case of welded drum this should be stress relieved.

8.4.8 *Strength of the Drum*

Drums shall be designed to withstand the compressive stress caused by the wound of wire rope, bending stress due to beam action and torsional stress.

8.4.9 *Rope Anchorage*

The end of the wire rope shall be anchored to the drum in such a way that the anchorage is readily accessible. Each wire rope shall have not less than two full turns on the drums when the hook is at the lowest position not taking into consideration the turns covered by the wire rope anchorage.

8.5 Sheaves

8.5.1 *Grooving*

Sheave shall have machined groove. The contour at the bottom of the groove shall be circular over a minimum angle of 120° and shall have an included angle of 50°. The grooves shall be finished smooth and shall be free from surface defects likely to injure the wire rope. The depth of the groove shall not be less than 1.5 times the diameter of the rope. The radius of the groove shall be between 0.53 to 0.59 times the diameter of the wire rope rounded of upwards to the nearest 0.5 mm.

8.5.2 *Diameter of the Sheave*

The diameter of the sheave measured at the bottom of the groove shall not be less than that at the drums specified in **7.4.6**. The diameter of the bottom of the groove at an equalizing sheave shall not be less than 62 percent at the minimum sheave diameter. The value is calculated as follows:

$$D_s = 12 \times d \times C_{df} \times C_{rc} \times C_{rr}$$

$$D_s = 8 \times d \times C_{df} \times C_{rc} \text{ for equalizing sheave.}$$

where

D_s = diameter of the sheave measured at the bottom of the groove in mm,

d = diameter of the rope,

C_{df} = duty factor for the appropriate mechanism class as defined in **7.4.3**. for hoisting,

C_{rc} = factor dependent on the construction of the

rope as defined in 8.4.6, and

C_π = co-efficient depending upon the type of receiving system.

For sheaves the value of the co-efficient C_π depends upon the number of pulleys in the reeving and the number of reverse bends.

Taking the values of

N_b = 1 for a drum,

N_b = 2 for a pulley carrying the rope in the same direction of wrap (no reverse bend),

N_b = 3 for a pulley carrying the rope in the reverse direction of wrap (reverse bend),

N_b = 0 for compensating pulley, and

N_t = is the sum of these values of N_b for the given rope reeving.

The corresponding values of the co-efficient 'C_π' are given in Table 5.

Table 5 Values of Coefficient C_π

N_t	< 5	6 to 9	≥10
C_π	1	1.12	1.25

8.5.3 *Lead Angle*

The angle between the wire rope and a plain perpendicular to the axis of the pulley shall not exceed 5°.

8.5.4 *Material*

Sheaves shall be manufactured from cast steel, or forged steel or rolled steel or from suitable grades of nylon.

8.5.5 *Sheave Guards*

Sheaves shall be provided with rigid guards to retain the wire ropes in the grooves. The guards shall fit close to the flange having a clearance not more than one-fourth of the diameter of the wire rope between the sheave and the inside of the guard. Bottom block sheaves shall be enclosed except for wire rope openings.

8.6 Track Wheels

8.6.1 *General*

Track wheels shall have cylindrical or tapered (conical) treads. With flanges or with the help of horizontal guide rollers they shall guide the crab or the crane effectively to prevent derailment. The wheels shall be mounted in such a manner as to facilitate removal and replacement. This clause gives criteria for determining the size of the wheels required to meet a particular duty. It is assumed here that the rail track is maintained in good condition and that the wheels are correctly aligned.

8.6.2 *Design Factors*

The factors those need to be considered when determining the required material and diameter for rail wheels are as follows when:

a) load on the wheel,

b) type and the material of the rail,

c) speed of rotation of the wheel (n),

d) length of travel (L) on the rail and number of load carrying wheels (Z) operating on the same length of rail, and

e) group classification of the mechanism.

8.6.3 *Wheel Hardness*

The minimum hardness of the wheel rim should be maintained 300 to 350 BHN with minimum depth of 10 mm. The formula for determination of wheel hardness is as follows :

$$BH_w = \frac{1.3 \times BH_r \times C_L}{C_z \times C_d}$$

where

BH_w = Brinnel hardness of the wheel rim;

BH_r = Brinnel hardness of the rail;

C_L = factor dependent on the rail length 'L' used by 'Z' number of wheels. For values refer Table 6;

C_z = factor dependent on the number of load carrying wheels 'Z' For values refer Table 7; and (*see* Fig. 4 and 5)

C_d = factor dependent on the wheel diameter 'D' For values refer Table 8.

8.6.4 *Material*

The material for the track wheels should be of C-55 MN 75 and also can be of steel or cast or wrought or shall have steel tyre shrunk on and registered with minimum hardness as obtained earlier. The steel shall not contain more than 0.06 percent either of sulphur

or phosphorus. For light duty cranes, cast iron wheels should be prohibited.

Table 6 Values of Co-efficient C_L
(*Clause* 8.6.3)

Length m	C_L
10	1.00
16	1.05
20	1.08
25	1.11
31.5	1.14
40	1.17
50	1.20
63	1.23
80	1.26
100	1.29

Table 7 Values of Co-efficient C_Z
(*Clause* 8.6.3)

Z in Nos. m	C_Z
2	1.00
4	1.08
6	1.13
8	1.17
10	1.20
12	1.22
14	1.24
16	1.26

8.6.5 *Loading Conditions*

In assessing the individual loadings arising under Case I and Case II loading conditions, the hook load impact factor is not applied.

8.6.6 *Diameter of Wheels*

The tread diameter of wheels shall be standardized to sizes 160, 200, 250, 315, 400, 500, 630, 710, 800, 900, 1 000 and 1 250 mm. The use of wheels of diameter greater than 1 250 mm is not recommended. The minimum tread diameter of the wheel may be calculated from either of the formulae given below:

Table 8 Values of Co-effcient C_d
(*Clause* 8.6.3)

Diameter mm	C_d
160	1.00
200	1.03
250	1.06
315	1.09
400	1.12
500	1.15
630	1.18
710	1.21
800	1.21
900	1.24
1 000	1.24
1 250	1.27

$$D = \frac{1.5\,W}{a}$$

or

$$D = \frac{W \times C_{df} \times C_{sf}}{1.5\,a \times C_{bh} \times C_{sp}}$$

where

D = tread diameter of the wheel in mm;

W = maximum wheel load in newtons;

a = useful width of rail;

C_{df} = duty factor for the appropriate mechanism class as defined in **7.4.3**;

C_{bh} = hardness factor for the wheel material. For values refer Table 9. Here wheel hardness B_{hw} = as calculated in **7.4.3** shall be used even if wheel rim if hardened more for longer wheel life;

C_{sf} = safety factor depending on the material used as defined in 7.4.3; and

C_{sp} = co-efficient depending on the speed of rotation of the wheel as defined in Table 10.

For a rail with a total width 'B' having rounded corners of radius r at each side and having:

a) Flat bearing $a = B - 2r$

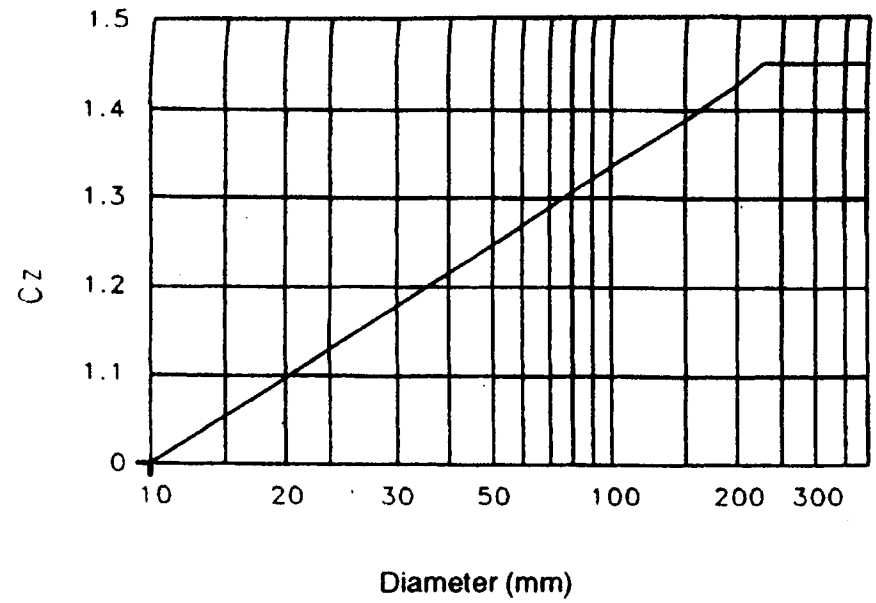


FIG. 4 SIZE FACTOR, C_z

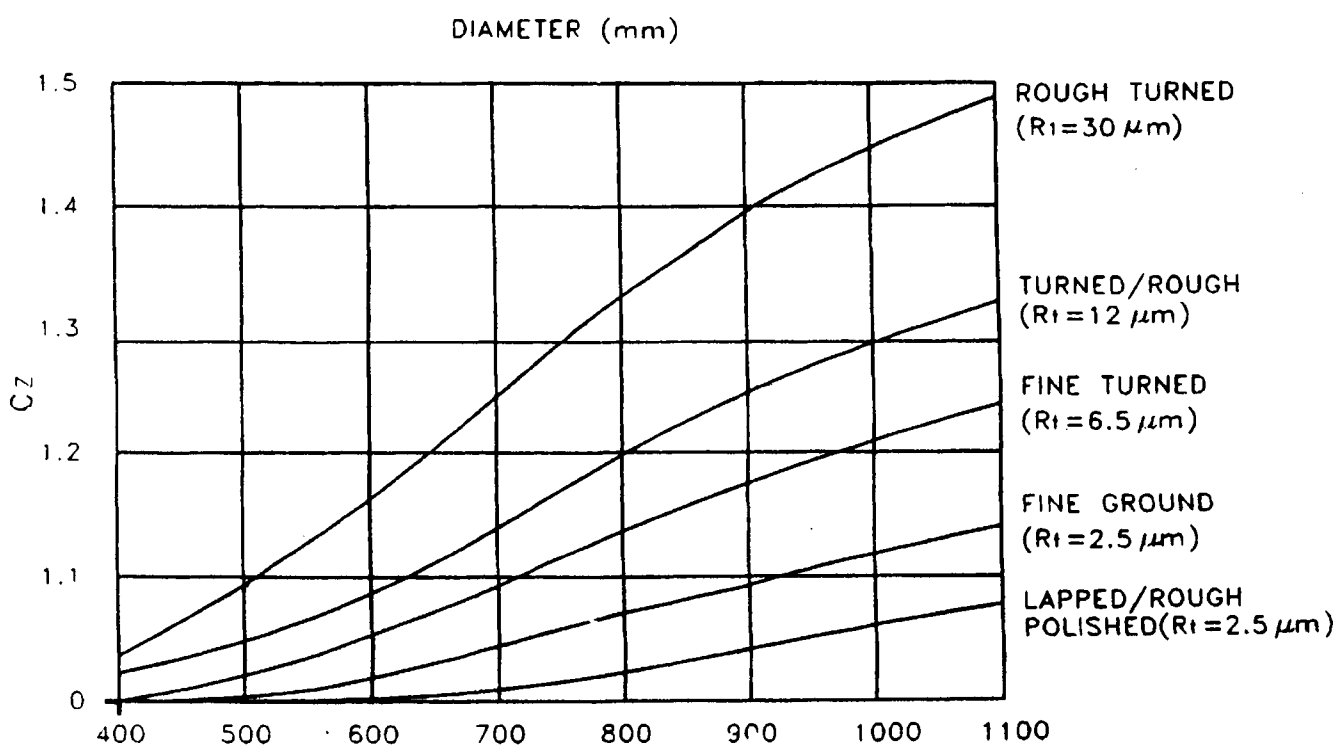


FIG. 5 SIZE FACTOR, C_z

Table 9 Co-efficient C_{bh}
(*Clause* 8.6.6)

B_{hw}	F_{ult}	C_{bh}
125	415	1.00
140	470	1.40
160	540	1.90
180	605	2.50
200	680	3.15
224	760	4.05
250	845	5.30
280	950	6.70
315	1 065	8.65
355	1 200	11.20
400	1 355	14.50
450	1 530	18.70
500	1 725	23.20
560	1 950	29.50

b) Convex bearing surface $a = B - \frac{4r}{3}$

where

B = width of the rail, and

r = radius of the rounded corners of the side.

8.6.7 *Determination of the Maximum Static Wheel Loading 'P_s'*

Where this shall be the maximum wheel load occurring with the wheel static upon the rail in any of the four cases of loading.

8.6.8 *Determination of the Mean Wheel Loading*

For loading conditions of 'normal service without wind' and 'normal service with wind' a mean wheel load shall be determined from the relationship by the formula given below.

$$P_{mean} = \frac{2P_{Max} + P_{Min}}{3}$$

where

P_{Max} = maximum wheel load, and

P_{Min} = minimum wheel load.

8.6.9 *Flanges*

The dimension of flanges for guiding track wheels at the base shall not be less than the values given in Table 11.

Table 10 Values of Co-efficient C_{sp}
(*Clause* 8.6.6)

Rotational Speed rpm	C_{sp}
200	0.66
160	0.72
125	0.77
112	0.79
100	0.82
90	0.84
80	0.87
71	0.89
63	0.91
56	0.92
50	0.94
45	0.96
40	0.97
35.5	0.99
31.5	1.00
28.0	1.02
25.0	1.03
22.4	1.04
20.0	1.06
18.0	1.07
16.0	1.09
14.0	1.10
12.5	1.11
11.2	1.12
10.0	1.13
8.0	1.14
6.3	1.15
5.6	1.16
5.0	1.17

Table 11 Minimum Flange Dimensions
(*Clause* 8.6.9)
All dimensions in millimetres

Diameter of Wheels	Depth of Flange	Thickness of Flange
160, 200, 250,	16	16
315, 400, 500	20	20
630, 710, 800, 900, 1 000	25	25
1 250	30	30

8.6.10 The flanges shall be adequately tapered to prevent it from rubbing on the rails. Fillets of radius 0.7 to 0.9 r shall be provided (where r is the radius of rail corners).

8.6.11 *Width of Tread*

The width of the wheel tread shall be greater than the rail head by an amount which shall suitably allow for the variations in the gantry rail alignment, gantry track span dimensions and crane span dimensions.

8.6.12 *Adhesion of the Drive Wheels*

To eliminate slipping of the drive wheels of the travelling mechanism of the crane or crab, the design shall be checked for adhesion under the most unfavourable combination of loads producing maximum and minimum loads on the drive wheels. The co-efficient of adhesion (friction) shall be taken as 0.15 for dry rails and 0.1 for damp rails.

8.7 Bearings

8.7.1 *General*

Bearing pedestals and mounting shall be capable of transmitting the load from the bearing to the supporting structure. Suitable provision shall be made for those cases where the resultant load is not acting as a compression load on a bed plate. Suitable anti-friction bearings shall be used for live or fixed axles for wheels, for the shafts used for sheaves and drums and for the shafts supporting gears.

Suitable steel bushing as used in bogies and steel bush bearings made out of phosphor bronze, cast iron or nylon can be used for hinges or balances of crane bridge or trolley, cross beams for hooks, magnet suspension, links for grab bucket and at places where rotation is not powered.

8.7.2 *Anti-Friction Bearings*

Anti-friction bearings shall be installed and fitted in accordance with the manufacturer's procedures with adequate provision for lubrication.

Arrangements for axial location shall be in accordance with correct practice so that unforeseen additional bearing loads are not introduced. Bearings shall be capable of withstanding the greatest static and or dynamic load it can be subjected to under whichever of the loading cases is the most unfavourable. The bearings shall have minimum static load capacity F_{sb} for a particular duty as given below:

where

P = maximum static load on the bearing under any load condition and for the equivalent load to be determined as specified by the manufacturer.

C_{df} = duty factor as defined in **7.4.3**. Life of the anti-friction bearings shall be calculated in accordance with the manufacturer's recommendations and based on working hours specified for the duty of the mechanism.

8.7.3 *Plain Bearings*

The selection, fitting, lubrication, the pressure and rubbing velocity shall be in accordance with the recommended practice and service experience for the material involved having regard to the nature of the loads and operating conditions. Plain bearings shall, where practicable, be of the adjustable cap type. If Phosphour Bronze bearings are used the pressure shall not exceed 6.86 MPa, wherein MPa is the unit of pressure.

8.7.4 *Lubrication*

Provision shall be made for the service lubrication of all the bearings unless sealed and lubricated for life. Ball and roller bearings shall, in addition, be suitably lubricated before assembly.

8.8 Gearing

8.8.1 *General*

All gears shall be machine cut hardened and profile ground and shall confirm to relevant Indian Standards. However the Crane gearings can be designed or selected on the basis of the conditions given below:

a) service experience under conditions corresponding to the classification parameters involved, or

b) other recognized standards or codes which have been proved satisfactory in crane service, or

c) any other method for making calculations where manufacturer must indicate origin of the method adopted if asked by the purchaser.

The gearing shall be designed for a service life compatible with the service life of the mechanism, the class of utilization and state of loading used for the mechanism, and having regard to the prime mover and brake.

8.8.2 *Material*

All gears shall be of cast or wrought steel of forged from low/medium carbon alloy steel and suitably heat treated.

8.8.3 *Gear Boxes*

All pair of gear boxes shall be so except for planetary gear boxes either spur or helical and gears shall be automatically oil lubricated designed that the first pair of gears shall always be helical and gears shall be automatically oil lubricated. The gears shall be readily removable and the boxes shall be oil tight. They shall be of rigid construction and fitted with inspection covers and lifting lugs where necessary. The inspection covers shall be so positioned that the first and second pinion shafts can be inspected. Minimum and maximum oil level indicators and facilities for oil filling, oil drainage and air breathing shall be provided.

All gear boxes shall be in totally enclosed construction. Teeth shall be machine cut, suitably hardened and tempered and shall conform to AGMA or IS 4460. The surface hardness of pinion shall be between 266 to 300 BHN and that for gear shall be between 217 to 255 BHN. Difference of hardness of pinion and gear must not be less than 20 BHN.

The gear box mounting shall be machine cut, hardened and profile ground to relevant Indian Standards and shall be seated and positively located on machined surface.

Material of the gear box shall be cast, wrought or forged from low/medium carbon alloy steel and suitably heat treated. The fabricated gear boxes shall be stress relieved before machining. The internal surfaces of the gear box shall be painted with oil resisting paint.

8.9 Couplings

All couplings shall be of cast, wrought or from forged steel, tooth portion to be heat treated to hardness HB 241-280 and also shall be designed to suit the maximum torque that may be developed. Solid and flexible couplings shall be aligned with the same accuracy so that they match accurately.

Hoist drums shall be connected to gear box output shaft by means of flexible drum couplings or barrel couplings to cater for misalignment, frame distortions, etc, and also to facilitate removal of hoist drum. Shaft couplings shall be as near as practicable to the bearings.

8.10 Fasteners

8.10.1 *Keys*

Keys and key-ways shall conform to relevant Indian Standards. Keys shall be so fitted and secured that they can not work loose in service.

8.10.2 *Bolts, Nuts, Screws and Washers*

All bolts, screws and set screws in rotating parts shall be locked. All other bolts and screws shall be fitted and locked if required by the purchaser so that they do not get loose. Bolts in tension shall be avoided wherever possible. All bolts, screws, nuts shall be made out of high tensile alloy steel material and shall be in accordance with relevant Indian Standards. Black bolts shall not be used. All bolts and nuts shall be easily accessible.

Tapered washers and tapered pads when used shall be tack welded in place. All washers shall conform to IS 1364 and IS 1367 respectively.

8.11 Buffers

8.11.1 *General*

Suitable buffers shall be fitted to each end of the end carriage assemblies and on both sides of crab or the bridge.

Buffers shall be so mounted to permit easy removal of wheels. Limit switches shall be provided in such a way that drive motors are switched off before the buffers are pressed. Buffers will be provided between the cranes if more than one crane is running on the same track.

8.11.2 *Type of Buffers*

Spring buffers, hydraulic buffers and buffers made out of resilient plastic, rubber or polyurethane may be used. Wooden buffers shall not be used. Buffers shall have sufficient energy absorbing capacity to bring the loaded crane or crab to rest from a speed 50 percent of the rated speed at a deceleration rate not exceeding 5 m/s^2.

8.12 Braking

8.12.1 *General*

a) The parts used for braking shall be made from hard wearing material with adequate thermal capacity for the duty required. Due allowance shall be kept for the brake drum capacity to dissipate heat generated due to frequent braking. The rubbing surface shall be smooth and free from defects. The brake lining shall be protected from water, grease, oil or other adverse effects.

b) The bearing pressure on the linings shall be conducive to uniform braking and long life. Brakes shall be provided with means of adjustment to compensate for wear.

c) All electro-mechanical or electro-hydraulic brakes shall be applied automatically by springs or weights when the power supply to the brake is interrupted or when the circuit breaker is opened or when the controller is brought to off position. Power applied brakes shall not be fitted without a back up system of power released type and without prior approval of the purchaser.

d) Springs of electro-mechanical brakes shall be of the compression type and shall not be stressed in excess of 80 percent of the elastic limit of the material. Brake weights if provided shall be securely bolted to the levers and locked.

e) Under service conditions brakes applied by hand shall not require a force greater than 120 N (12 kgf) at the handle. Brakes applied by foot shall not require a force of more than 200 N (20 kgf) on the pedal. The stroke of hand levers shall not exceed 300 mm and of pedals 150 mm. Locking devices shall be provided on brake levers where necessary. Brake pedals shall have non slip surface.

f) Electro-hydraulic thruster operated brakes are permissible on all motions.

g) Appropriate mechanical, electro-hydraulic brake magnet or any other alternative brake releasing gear may be used.

8.12.2 *Braking Path*

The braking path of the crane motions shall be within the distance as calculated from the following formula with all the brakes applied simultaneously unless required otherwise by the purchaser:

$$S = \frac{V}{C_b \times C_{df}}$$

where

S = braking path in metres,

V = speed of motion in metres/minute,

C_{df} = co-efficient for group classification and type of motion as defined in 7.4.3, and

C_b = 80 for hoisting motions,
= 20 for travel motions.

8.12.3 *Hoist Motion Brake*

All electrically operated hoisting motion shall be fitted with an electro-hydraulic/electro-magnetic fail safe brake. The brake will arrest the motion and hold at rest any load up to and including overload test load at any position of the lift.

The provision shall be made to enable any load capable of over coming the friction in the system up to and including the test load to be lowered safely in a controlled manner in the event of power failure. The brake shall be designed to exert a restraining torque of minimum 50 percent greater than the maximum torque transmitted to the brake from the suspended load under the loading conditions as specified in 7.3. In estimating this torque the effects of friction in the transmission system between the load and the brake shall be ignored.

Cranes handling dangerous liquids be fitted with an independent delayed action type additional brake on the hoisting motion. Each of these two brakes shall have minimum braking torque of 125 percent of the computed full load torque.

Total torque of the externally applied brakes, acting simultaneously, shall not be more than the total pull out torque of the motors.

8.12.4 *Travelling Motion*

Every electrically operated travelling motion shall be fitted with a mechanical or hydraulic brake or an automatic electro-magnetic / electro-hydraulic brake or a combination of the two, if required. The brake shall be capable of bringing a fully loaded crane to rest with least possible shock from the highest speed it can attain with electro-magnetic/electro-hydraulic brakes, limit switches shall be provided in this motion.

The travelling motion of every electric outdoor crane shall be provided with the automatic electro-magnetic/electro-hydraulic parking brakes if the service brake is not of eletro-mechanical type. All overhead cranes working outdoors shall be provided with an additional storm brake for anchoring it when it is left unattended or under the storm condition. Gantry cranes working outdoors with rails on ground shall be provided with rail clamps or screws jack or chain anchor at each corner for anchoring it during the storm.

The braking torque shall not be less than the full load torque transmitted to the brake and shall not be more than the pullout torque of the motor.

8.12.5 *Traversing Motion*

The cross traverse motion should also necessarily be provided with brake/brakes as specified for long travel motion. When electro-mechanical brakes are provided, end limit switches shall be provided in this motion.

The cross traverse motion brake(s) shall be capable of bringing the fully loaded crab to rest with least possible shock from highest speed it can attain.

The braking torque shall not be less than the full load torque transmitted to the brake and shall not be more than the pullout torque of the motor.

9 GUARDING AND WEATHER PROTECTION

9.1 Guards

All gears, wheels, pinions and chain drives shall be totally encased by the guard or by the structure of the crane, so as to be safe as if complete encasement is provided. Effective guards shall be provided for all revolving shafts and couplings rotating at high speeds or having protruding parts or are so situated in relation to the structure of the crane as to be safe as if guards were provided. The sheaves of the hook block shall be guarded to prevent the possibility of trapping between a sheave and the in-running wire rope.

Suitable guards shall be provided on the down-shop lead side to prevent accidental contact between wire ropes or hook block or lifting attachments and live conductors. It is also suggested that all guards and protective equipment shall be painted in 'Golden Yellow' or as in confirmation to relevent Indian Standards. This is required to identify about the location of the guards and protective equipment in the crane easily for the replacement of the guards/ protective equipment while commissioning or while the crane is taken up for maintenance work.

9.2 Weather Protection

For outdoor crane all electrical and mechanical equipments shall be adequately protected from the weather. All weatherproof covers shall be easily removable.

9.3 Painting

Before dispatch of the crane, the complete crane covering structural, mechanical and electrical parts shall be thoroughly cleaned of all dirt, grease, scale and rust by shot blasting or chemical cleaning methods. A single coat of primer shall be given to all parts exposed to the weathering effects and if are not already treated earlier or effectively lubricated. At least two additional finishing coats of paint for indoor cranes/ outdoor cranes of colour of customer's choice shall be given on all primer painted surfaces.

All moving parts up to the height of 5.0 m from working level or ground shall be painted in 'Golden Yellow' colour. The bright exposed parts of the crane shall be given one coat of rust inhibitor. Interior of all gear boxes shall be painted with one coat of oil resisting paint. Areas that are inaccessible after assembly or erection shall be treated before assembly or erection.

Where the cranes are supplied for use in abnormal working conditions special protection may be necessary.

Any additional requirements regarding painting shall be as agreed between the purchaser and the manufacturer.

10 LUBRICATION

Provision shall be made for lubricating all bearings unless sealed or lubricated for life, matting gears and chain and sprockets arrangements. Where necessary easy access shall be provided.

In case centralized lubrication system is asked by the purchaser, provision shall be made at the bearings to vent the lubricant pressure.

Lubricating nipples, pipes, and adopters shall generally comply with the relevant Indian Standards.

A lubricating chart shall be provided indicating all the lubricating points with 'Red colour' paint, the type of lubricant and recommended frequency of lubrication.

11 MOTION LIMITING DEVICES

11.1 Hoisting Limiting Devices

Positively operated hoisting motion limiting devices shall be provided that stops the upward and downward motion when predetermined level is reached to prevent over winding or over unwinding.

NOTE – The limiting device shall be regarded as a safety feature and not as a routine operational means of stopping. Where normal operation of the crane necessitates frequent approach to the upward limit, an additional motion limiting device shall be provided that operates independently and requires manual resetting.

11.2 Cross Traverse and Long Travel Limiting Devices

Limiting devices shall prevent the following conditions:

a) over traversing and over travelling, and

b) collusion where two or more crane/trolleys operating on the same track.

11.3 Load Indication and Load Limiting Devices

Load indication and limiting devices are recommended if weights of objects to be lifted are not known accurately. When fitted, they shall sense the load on the crane by means other than the current consumed by the hoist motor. If the load lifted is more than S.W.L. load limiting devices shall stop further hoisting operation till the load is removed or reduced.

11.4 Drawings and Documents

Following drawings and documents shall be submitted for approval of the purchaser before manufacturing of the crane:

a) GA drawing of the crane;

b) GA drawing of crab/trolley;

c) GA drawing of individual mechanisms;

d) Drawing of bridge, end girder and their connection;

e) Sub-assembly drawing for wheels, hook blocks and hoist drums;

f) Calculations for selection of motor, reducer, brake, couplings, etc; and

g) Calculation for bridge girder end carriage and their connections.

SECTION 3 ELECTRICAL

12 MOTORS

12.1 General

The motors shall be selected to take care of loading conditions as given in 7.3.2 and to suit the duty of the mechanism in which it is used. The motors shall be suitable for frequent reversing, frequent acceleration and braking.

12.2 Selection of Motor Sizes

When the duty cycle can be adequately assessed, d.c. or a.c. motors for any crane motion may be selected so that the motor temperature in actual service shall not exceed the permissible limits specified in IS 325 for three phase induction motors or other relevant Indian Standards (*see* Annex F), taking into account the class of insulation adopted and the ambient temperature at the crane location. When duty cycle can not be assessed the recommended assumptions and design proceedings are set out in Annex C for the selection of motors to suit duty cycles and normal service conditions.

dc Motors shall be series wound and ac motors shall be squirrel cage or slipring induction type unless specified otherwise. The dc motors should be selected in agreement with their manufacturer's. It is necessary to know the torques, the power calculated and the true operating conditions of the motor.

NOTES

1 Motor power as computed in Annex C has been multiplied by service factor to make the motor thermally capable for the duty condition. While designing controls, the crane manufacturer should use computed motor-power without service factor for selection of components. The components selected should be able to carry the full load current of the motor power computed without service factor at the specified duty cycle and ambient temperature of operation of the crane.

2 If specially required by the purchaser, the drive motor should be protected against over heating by means of thermistors embedded in the motor windings. Matching thermistor trip relay should be provided in the control panel.

12.3 Enclosures

All crane motors shall be totally enclosed with or without fan cooling arrangement and shall conform to IS 325, IS 1231 or IS 2223 as appropriate. The enclosures shall suit the specified service conditions and shall be stipulated with the enquiry or order. If not specified by the purchaser the motor enclosure shall be minimum IP 44 for indoor applications and IP 55 for outdoor applications of ac motors and IP 23 for dc motors. For outdoor applications separate canopy shall be provided for motors.

12.4 Torque Rating

The motor shall be capable of producing maximum torque required to produce motion in the most unfavourable loading condition. The pull out torque of the motor at rated voltage and frequency should not be less than 2.0 times the rated torque for the all mechanism classes from M1 to M8 as corresponding to computed motor power without service factor.

12.5 Limiting Speed

Motors shall be capable of withstanding a maximum speed of 2.5 times rated speed or 2 000 rev/min, whichever is less.

12.6 Insulation

The motor shall be of Class B insulation or better as classified in the relevant Indian Standard specifications.

12.7 Accessibility

Motors shall be so located that the brushes, gear and terminals are accessible for inspection and maintenance.

12.8 Terminals

Motor leads shall be brought out from the motor frame to terminals in the terminal box fixed to the motor frame and shall be marked in accordance with IS 4728.

12.9 Sliprings

Slipring motors shall have continuously rated sliprings amply dimensioned to give a long trouble free life.

12.10 ac Motors may be supplied in IEC frames and dc motors in AISSE frames.

12.11 Higher frame size such as above 280 ac motors should have bar wound rotor.

13 ELECTRIC BRAKING (ELECTRO-DYNAMIC BRAKING)

13.1 General

Electro-mechanical braking is referred to an automatic electric brake whose action is purely mechanical and the braking effect is nullified electrically by a solenoid, or electro-magnet, or electro-hydraulic release gear. In electric braking the energy is either returned to the line or dissipated in resistors. In addition to the specific requirements of this code for the brakes and irrespective of the supply current, electrical braking is permissible on all motions of electrically operated cranes.

When electrical braking is used, provision shall be made to limit the current on reversal to a safe value. Effective means shall be provided for stopping the motion in the event of a power failure and in the case of an emergency.

Shunt brakes shall be so connected that it will be applied when the main circuit-breaking device is open irrespective of the position of the controller. If required by the purchaser, each control circuit shall be electrically inter locked with all associated shunt breaks to prevent power being applied to the motion when the brakes are not energized.

NOTES

1 If a hoist is potentiometer controlled, an auxiliary pole is required on the main circuit-breaker to open the shunt brake and control circuits.

2 In case of hoist motors, either the brakes are released with the energization of motors or the motors are energized.

13.2 Brake Magnets

The terminals of brake magnets shall be protected from accidental contact. The connections and windings shall be effectively protected from mechanical damage. Where necessary, magnets shall be provided with an efficient cushioning device. Ratings of brake magnets and thruster brake motor shall be as given in Table 12.

NOTES

1 CDF means 'Cycle Duration Factor'.

2 The temperature rise of the brake electro-magnet or thruster at any of the specified duty mentioned above shall not exceed permissible limits for the particular class of insulation used with due consideration of switching current in rush (due to field forcing in case of dc magnet).

3 Maximum duration of cycle shall not exceed 10 min in case of intermittent duty. The brake magnets shall operate at the currents and voltages given in Table 13.

4 Arrangements shall be made, where necessary, to prevent the brake magnet from being energized by the back 'emf' of the motor when the supply has been interrupted.

Table 12 Rating of Brake Electro-magnets and Thruster Brake Motor

Type of Actuating Device	Rating	
	Duty in Percent CDF	Permissible Switching
dc Magnets	20 40 60 100	720
ac Magnets	20 40	120
ac Magnets	60 100	60
ac Thruster brake motor	60 100	720

14 CRANE CONTROLLING ARRANGEMENTS

14.1 General

The type of controls to be used shall be as agreed between the manufacturer and the purchaser. Cranes having alternative control or brake circuit facilities shall be provided with means to prevent operation from

more than one facility at any one time.

NOTE — Main circuits are those which carry main motor or magnet current. Control circuits with brake circuit mechanism are those which are used for control equipment for main motor or magnet.

Table 13 Brake Magnet Operating Currents and Voltages
(*Clause* 13.2)

	Windings	dc Magnets	ac Magnets
Series	For series resistor control	Lift at 60 percent rated current Hold at 15 percent rated current	
	Potentio-meter control	Lift at 40 percent rated current Hold at 15 percent rated current	
Shunt		*Lift at 85 percent rated voltage * Hold at 50 percent rated voltage	*Lift at 85 percent rated voltage *Hold at 50 percent rated voltage

*This is intended to apply with hot coils corresponding to the duty cycle at rated voltages. The temperature rise of the brake magnet shall not exceed that allowed for the control equipment fitted.

14.2 Controllers

Controllers shall be rated to comply with the relevant Indian Standard specifications. Controllers shall be adequately protected to prevent accidental contacts with the live parts. Controllers in 'off' position shall open all supply lines of the respective motors, unless otherwise agreed to, in which case a warning notice shall be fixed to the controllers. On or adjacent to each control device, there shall be a durable marking identifying the motion controlled and the direction of movement.

14.2.1 *Control Equipment for dc Motors*

Contactors, switches and allied electrical components shall be selected on the basis of calculated power in (kW) of the motor.

14.2.2 *Control Equipment for ac Motors*

The selection of contactors shall be made on the basis of S 3 - 40 percent rating arrived after applying appropriate service factor to the computed power of the motor. The rating of the control gears such as switches, overloads, etc, shall be selected according to the computed motor power without the service factor of the motion served and not on the motor power computed by the thermal requirements.

The contactors selected under **14.2.1** and **14.2.2** shall have the stipulated contact life as may be specified by the user.

14.3 Controllers Provided in the Cabin

14.3.1 *General*

All control handles and pedals shall be placed in convenient position to allow the driver ample room for operation and permit an unrestricted view of the load. They shall be so disposed that the contacts and terminal arrangements are readily accessible for inspection and maintenance purposes.

14.3.2 *Marking Direction of Operation of Controllers*

Where practicable controller handles shall move in the direction of resultant load movement. Each controller shall be marked in a permanent manner to show the motion controlled and direction of movement. For vertical lever handle operating hoist controllers, movement towards operator shall indicate hoisting and movement away from operator shall indicate lowering.

14.3.3 *Notching*

The notching for the controller handle in the 'off' position shall be more positive than the notching in other positions. The handle may be provided with a lock, latch, dead man or spring return feature if specifically requested by the customer. The control lever shall be provided with stops and/or catches to ensure safety and facility of operation. A controller drum fitted with a star wheel shall be regarded as complying with the requirement.

14.3.4 *Master Controller*

Master controller operated cranes shall be provided with automatic control of acceleration. Accelerating torque/current peak shall be limited during controller handle movement from one notch to the other with due consideration to the pullout torque of the motor

and number of rotor accelerating contactors shall be selected accordingly. For master control operated cranes the control voltage preferably 110 ac and shall not exceed 240 V for ac or dc supply.

14.4 Pendant Controllers

14.4.1 *General*

Cranes with pendant controls shall not have long travel speed in excess of 40 m/min. Pendant control may either descend from the crab or from the independently travelling trolley or from a convenient position on the crane bridge.

14.4.2 *Pendant Switches*

The pendant switches shall be capable of withstanding rough handling without being damaged and the cover shall be effectively secured. If control is from the floor, the electrical control circuit to the pendant shall be energized at not more than 110 V dc or ac supply.

14.4.3 *Pendant Control*

On all pendant controlled cranes means shall be provided to prevent inadvertent operation from the floor while maintenance work is being carried out on the crane. An isolator fitted on the crane bridge, which can not be operated from the floor will comply with this requirement.

14.4.4 *Pendant Control Station*

If the control is by push buttons or switches, they shall automatically return to the 'off' position immediately after they are released. One lockable type push button shall be provided to switch off control power when the crane is not in use and if other means of switching off is not available.

14.4.5 *Suspension of Pendant Switch*

The weight of the pendant shall be supported independently of the electric cables by means of chain or wire rope. If the pendant enclosure is of metal it shall be effectively earthed. A chain or hook does not provide effective earth connection.

14.5 Radio Control System

14.5.1 Main features of radio control system consist of:

a) A portable transmitter,

b) An antenna and receiver on the bridge, and

c) An intermediate relay panel on the bridge to amplify the signals for the crane contactors.

14.5.2 Radiocontrols should be designed so that if the control signal for any crane motion becomes ineffective, that crane motion will stop, and conversely signals received from any source other than the transmitter will not result in operation of any motion of the crane. The crane must not take off on its own or respond to or generate false commands. In case electricity failure occurs, the crane must stop.

A key switch or equivalent security device on the transmitter that can be used to prevent unauthorised use of the transmitter.

The sending of a continuous or continuously repeating secure signal when transmitter is in use, which the crane receiver can identify. A secure signal includes at least three characteristics separately recognizable by the receiver.

An emergency stop device shall be used for emergency stop.

A carrying harness, belt, shoulder strap or lanyard on the transmitter.

14.5.3 The arrangement of the operating levers on the radio transmitter should conform to Fig 2A. The manufacturers should supply motion switches with different shaped knobs so that the motion can be selected by feel and the operator's vision remain on the load. Modular construction shall be preferable for easy replacement.

14.5.4 Typical frequencies used for radio controls are in between 450-470 MH for which licence is required. The recommended crane controls for operating are of maximum 250 metre range.

Radio crane control transmitter lever arrangement are of four motions, namely, are given below:

Bridge	*Trolley*	*Main Hoist*	*Aux Hoist*
X	Y	Down	Down
O	O	O	O
W	Z	Up	Up

Radio crane control transmitter lever arrangement are of three motions, namely, are given below:

Hoist	*Bridge*	*Trolley*
X	X	Down
O	O	O
W	Z	Up

NOTES

1 Markings on the crane visible from the floor, shall indicate the direction of bridge and trolley travel corresponding to the W, X, Y and Z designations on transmitter.

2 The maximum working range of radio control shall be limited to 40 - 50 m from the transmitter. This limitation reduces the likelihood of an accident caused by the crane operating beyond the operator's visibility.

3 It is recommended that a device is fitted to the crane to give warning that the crane is under non-conductive control.

4 Incorporate a limited range feature, present by means not available to the operator so that the crane will stop when the extent of that range is reached.

5 If more than one crane are provided with this type of controls, only the intended crane and its motion is operated at one time. The transmitter shall be constructed so that it is capable of withstanding rough handling.

14.6 Control Circuits

If the mains supply is ac and the control circuits are supplied at reduced voltage, the supply to these circuits shall be from the secondary winding of an isolating transformer or an isolating transformer and rectifier. The transformer frame and one pole of this supply shall be earthed and the contactor and relay coils shall be connected to this pole. An earthed screen shall be provided between the primary and secondary winding. The primary winding and unearthed pole of secondary winding of the transformer shall be protected by fuse in line connection. Effective means shall be provided to prevent mal-operation owing to short circuits or earth faults.

14.7 Rectifiers

On ac cranes, if dc supply is required, rectifiers shall be provided for supplying the control circuit, brakes and magnets. These rectifier units shall be of adequate capacity to supply the full dc loads required continuously. They shall be of suitable construction and mounting to withstand heat, dust, shock and vibration. Silicon type rectifier units shall be preferred. Adequate fuse protection shall be provided for the rectifiers. Rectifiers/thyristors used for magnets shall be protected against switch surges.

14.8 Control for dc supply

When a dc supply circuit is used, motor acts as a generator in the lowering direction, the control shall be such that:

a) motor shall not exceed a predetermined maximum revolutions per minute,

b) progressive degrees of braking is provided,

c) adequate light hook lowering speed is provided,

d) the brake is prevented from being released by back emf of the motor when power supply is interrupted, and

e) the electro-mechanical brake is automatically applied when circuit breaker or contactor is opened.

14.9 Braking Controls

When an electro-mechanical brake is used as an emergency or parking brake or when such an emergency or parking brake is used with hand or foot operated travel service brakes, the brake actuating device shall remain in the circuit when the main circuit breaker is closed. The brake shall apply automatically when the power supply fails or when the circuit breaker is opened or on operating an emergency stop push button or switch; but not when the controller handle is brought to the 'off' position.

The brake shall lift off when voltage at the coils is a minimum of 85 percent of rated voltage. Provision shall be made for emergency application of this brake by means of the emergency stop push button or switch.

In the arrangement of connections to the hoisting motion brake coils, means shall be provided to ensure that when associated drive motors are de-energized, the stored electrical energy in these motors will not delay the application of the brake.

14.10 Acceleration Control

Automatic control of acceleration shall be provided for all crane motions, unless for any motion another control system is specified. The hoist motion circuits shall enable any load to be lowered with safety and the hoist motors shall remain under effective control with the controller in all positions. While calculating the number of rotor contactors, peak accelerating/ decelerating torques and pull out torque of the motor should be taken into account.

For creep lowering speed on hoisting motion, relatively flat speed control shall be provided.

14.11 Markings on the Crane

When the control devices are other than in a fixed position relative to the crane, the designation of horizontal directions marked on the control device shall be marked on the crane so that it is clearly visible to the driver.

15 PROTECTIVE EQUIPMENT

15.1 General

Suitably located efficient means shall be provided to protect every part of a system from excess current and voltage to prevent danger or damage. Enclosures having minimum degree of protection IP 44 shall be provided for all electrical equipments except for motors and resistors.

15.2 Electrical Protective Device

15.2.1 *General*

If electrically operated contactor equipment is used for control of all crane motions, the protective equipment shall be in accordance either with Scheme A, in which each motion has separate protection, or with Scheme B, in which an overload of any motion trips off the crane supply. If drum controllers or master controllers are used for the control of all motions, the protective equipment shall comply with Scheme B. Also it is more often required that in master controller operated crane, overload of any motion should not trip the complete crane circuit, but should trip the individual circuit.

In general, overload protection shall be of electro-magnetic type with time delay. Thermal overload relays in conjunction with high rupturing capacity fuses or manual reset type overload relays may be provided if agreed by the purchaser.

Where a motion is ward-Leonard controlled, provisions shall be made for:

a) protection in case of motor field failure;

b) protection against the motor creeping when the controller is in the 'off' position; and

c) tripping of the generator field circuit with suppression of generator voltages instantaneously when there is an over current of 250 percent in the generator-motor loop; or after a time-lag when there is a sustained over current of lower value.

Operation of any of the above protective devices shall automatically apply the electro-mechanical brakes on the relevant motion. If other systems of control or mixed systems are specified, the protective equipment shall be in accordance with the recommendations of the controlgear manufacturer. An indelible circuit diagram of the protective equipment shall be provided in the electrical equipment compartment.

15.2.2 *Protective Device Common to all Motions*

As minimum equipments of protection, electro-magnetically operated contactors or manually operated circuit breakers fitted with no volt release, capable of cutting off the power supply to the motion drives with under voltage protection shall be provided. Adequate protection against short circuit shall be provided at each of the isolator positions. The circuit breaker of the main contactor shall be rated to carry at least the combined full load currents of motors for any two motions having largest powers and auxiliary loads such as magnet, etc. If specified by the purchaser that more than two motions may be operated simultaneously, circuit breaker/main contactor shall be rated to suit the requirement. In appropriate cases, high rupturing capacity fuse may be provided.

The circuit-breaker shall incorporate thermal and electro-magnetic overload protection device for protection against sustained overload and short circuit condition. If adequate protection against short circuit is to be provided at each isolating positions, there will be either HRC fuses or MCCB /ACB in each isolating position. As HRC fuses may lead single phasing, only MCCB should be provided in each isolating position. The circuit breaker or main line contactor should not be rated to carry magnet full load current as magnet supply is taken before the circuit breaker/main line contactor. The breaker shall have adequate rupturing capacity to withstand and clear fault current of the system. If specified a suitable control circuit may be provided for this circuit-breaker to prevent it from being closed when the main contactor of a particular motion has failed to open, although the corresponding controller has been brought to its 'zero' position.

15.2.3 *Scheme A Protective Device for Individual Motions*

The provision of overload protection with adjustable inverse time log overload release shall be under-voltage release and with overload. The minimum provision of overload protection shall be such that all supply lines except one to each motion shall be provided with adjustable inverse time-lag overload releases. These shall be connected as close as possible to the contractors they control and shall be set to trip the circuit of the motion controlled when carrying 200 percent of the full load current of the motor, after a time-lag of not more than 10 s.

It shall not be possible to reinstate the current supply to the contactor closing coils of a motion until the master controller for that motion is returned back to the 'off' position.

15.2.4 *ac Instantaneous Release Single Pole Over Load : Protective Device for Individual Motions*

Any motor having its power less than one-third that of the largest motor and served by the same common overload release, shall be protected by a separate overload release. However, normally instantaneous release of overload relays are not used for individual motion and circuit breaker is tripped by its own overload. In crane with circuit breaker overload protection is provided by circuit breaker. In cranes with line contactor one tripple pole magnetic overload relay rated for total crane power may be provided to trip the main contactor

Adjustable overload releases shall be provided to trip the main contactors or circuit-breakers and shall be connected as close to them as possible. The minimum provision for over current protection shall be as given below:

a) one instantaneous release in a common line feeding all motions set to trip the main contactors or circuit breakers instantaneously when the current rises to 250 percent of the value specified above; and

b) one inverse time-lag release in each other line feeding each motion, set to trip the respective motion when carrying 200 percent of the full load current of the line, after a time-lag of approximately 10 s.

It shall not be possible to reinstate the current supply to the common main contactor closing coils, or complete the under voltage circuit of the circuit breakers until the master controllers for all motions are returned to the 'off' position.

15.3 Protective Devices for Motor Circuits

The number of overload devices and their position shall normally be in accordance with the arrangements shown in Table 14. If specified by the purchaser, other arrangements giving protection not less than any of these shall be considered as complying with the specification.

Table 14 Normal Requirements for Number of Protective Devices for Circuit

dc Supply		3-Phase ac Supply
No Line Earthed	One Line Earthed	
2 per motion in separate lines	1 per motion connected in the non-earthed line	3 per motion in separate lines

15.4 Contactors

Reversing contactors shall be interlocked, preferably mechanically as well as electrically so that only one directional contactor can be in the closed position.

15.5 Control Switch Fuse

Operating coil circuit of the main contactor or control contactor in case of cranes with circuit breaker. A double pole control switch fuse shall be connected in the operating coil circuit of the contactor. Miniature circuit-breaker as an alternative to control switch fuse may also be used.

15.6 Emergency Switches

A mushroom head push button or a prominent switch for emergency stop shall be provided at each control facility to switch 'off' the total crane supply or to de-energize the main contactor common to all the motion drives. In the case of dc cranes, rheostatic braking shall be applied to the hoist motions. When any circuit-breaking device is open no main pole on the nominally dead side shall be made alive by a parallel circuit in emergency.

The emergency switch shall be so located as to be readily available for prompt use by the operator in case of emergency. If specified by the purchaser or when the crane span is larger than 20 m, the number of emergency stops shall be more than one. A reset button shall be provided if required by the purchaser. The emergency stop push-buttons or switches shall be connected in the operating coil circuit in the case of a contactor and in the under voltage release circuit in the case of a circuit breaker.

15.7 Off-Position Interlocking

Electrical interlocking shall be provided to prevent inadvertent starting of the motions, in the case when power is lost, without the controller being brought to the 'off' position on restoration of the supply.

15.8 Pilot Lamp

A red pilot lamp shall be connected to indicate that the crane is ready for operations and it shall be so located that it is visible to the operator. The pilot lamp shall be connected so that it indicates whether the control supply is ON or OFF or the contactor is CLOSED or OPEN.

15.9 Thyristor Control Main Features

a) The thyristors shall be protected by fast acting semiconductor fuses having $12 \times t$ value

considerably lower than that of the thyristors. These fuses shall be continuously monitored so that blowing of any fuse shall result in tripping of the power circuits.

b) The thyristor shall be suitable to carry at least 200 percent of the drive motor current rated S3-40 percent. The PIV of the thyristor shall be 2.5 times the system peak voltage appearing across the thyristors. The factor 2.5 has been selected taking into account the line voltage variations.

c) Each thyristor shall be protected by RC snubber circuits so as to absorb the surges generated out of external line surges in consultation with the user.

d) The drive system shall be protected against overload by means of thermal overload or oil dash pot of magnetic overload type with inverse characteristics having adjustable setting range. It shall also be protected against over current by means of instantaneous acting over current relays having a setting range of 200 to 400 percent of the drive rated current. Solid state overload protection may be used subject to the agreement of the purchaser. Preferably thermal overload protection to be used instead of magnetic overload relays as the thermal overloads have a reset time which would prevent the drive from restarting back immediately.

e) Switching-off of reversing contactors shall be done at near zero current. This is to be done by ensuring that the stop/tripping command first inhibits the thyristor controller and then switches 'off' the reversing contactors. This requirement will not be applicable if the reversing is through thyristors.

f) In the case of overloading or the single phasing of the synchronising supply, the circuits shall be tripped immediately.

g) Whenever armature reversal (in case of the dc drive) or stator reversal (in case of the ac drive) is to be done through the reversing contactors, the drive shall be protected against the free fall conditions at the time of switching on and reversals by having the prefered switching state of the reversing contactor. The drive controller shall have suitable provisions for preventing load drifts at the time of start and stop.

h) For achieving smooth acceleration of the drive mechanism suitable ramp generator circuit shall be available with the controller.

j) Wherever necessary, suitable deration would be considered for a.c./d.c. motors in consultation with the thyristor controller manufacturer and the motor manufacturer.

k) The control circuits shall be so designed that the brakes are applied at around the zero speed.

m) Test points shall be available in the cards.

n) In case of wide deviation of the speed in actual value from the set value, the circuit shall trip the mechanism immediately. During acceleration or deceleration period such tripping shall be prevented by adjustable time setting.

p) Thyristor control shall be suitable for operation at vibration levels and environments encountered in the crane operation.

q) If specially required by the purchaser, the drive motor shall be protected against overheating by means of thermistors embedded in the motor winding. Matching thermistor for trip relay shall be provided by in the control panel. The embedded thermistors are best for preventing overloads and subsequent overheating of the motor as these thermistors give the correct thermal image of the motor irrespective of the current carried.

r) Wherever a.c. phase controllers are to be paralleled for load sharing, the convertor outputs shall be paralleled only at the load end and not at the convertor end.

15.11 Special Protection for Direct Current Drive System

a) To minimize excessive rate of rise of armature current and radio frequency interference, commutating chokes with sufficient inductance shall be provided on the ac side so that PU (inductive drop) across the choke lies between 2 to 4 percent. Where isolating transformer is used, commutating chokes are not necessary.

b) To prevent excessive wear and tear of the commutators, the ripple content of the dc output shall be minimized by providing smoothening chokes of sufficient inductance depending upon motor design.

c) In case of the four quadrant drives, to protect

against inverter commutation failure during regenerating mode, branch thyristor fuses shall be used. However, where it is not possible to use branch thyristor fuses, there shall be at least one fast acting semi-conductor fuse on the dc side of the converter in addition to the semi-conductor fuses on the ac side.

d) While switching on the system, the following sequence shall be adhered to:

   i) Synchronizing supply is switched 'ON',

   ii) Field circuits are established, and

   iii) ac/dc contractors are switched 'ON'.

e) The drive shall be protected against field failure with suitable circuits.

f) The field current shall be reduced to a safe value during the crane idling time to reduce the heating of the motor. The normal field current shall resume at the start of the drive operation.

15.12 Main Feature of Built-in Crane Weighing System (Load Cell)

a) The load cell shall be of compression type and IP 68 protection.

b) The power supply shall be 230 V ac or 110 V ac 50 Hz single phase.

c) The load cell shall be placed in such a way that the load which is inert on the equalising pulley/bar is transferred to this load cell by a pivot assembly.

d) The built-in crane weighing system should have local indicator, processor based type, LED display, IP 55 protection, shall be located on the control cabin of the crane.

e) The built-in crane weighing system should have remote indicator, LED display type, minimum visibility range of 50 m, shall be located on the crane girder.

f) The resolution shall be in the order of 5 kg.

g) The system shall have the provision of tripping the circuit in case of overloading the cranes and should serve on an additional overload safety device.

16 ISOLATION

16.1 General

Means shall be provided at easily accessible positions on the crane for isolating the crane from the power supply close to the connector or terminal box in the case flexible cables are used. These shall take the form of isolating devices fed in parallel as follows:

a) for motion drives,

b) for auxiliary circuits, and

c) for the lifting magnet, if fitted.

16.2 Isolating Device for Motion Drives

The isolating device for the motion drives shall be capable of interrupting the stall current of the largest electric motor fitted to the crane or combined full load currents of the motors of any two motions of the crane using the largest power (kW) working together which ever is more and working together with auxiliary loads. Main switches used for isolating shall comply with the relevant Indian Standards. This isolating switch shall be unfused, unless high breaking capacity fuse protection is specified.

16.3 Isolating Switches and Isolators

16.3.1 *Cabin Operated Cranes*

For all cabin operated cranes a main isolating switch shall be fitted in the cabin or adjacent to it capable of cutting off the supply for all power driven and associated equipment on the crane, except auxiliary connections such as warning lights, lighting, fan and heating circuits, air conditioners, magnet circuits and communication circuits.

When the operator's cabin is fitted to the trolley and moves in relation to the main crane structure, an isolating switch outside the crane cabin shall be provided in addition to the isolating switch in the operator's cabin.

16.3.2 *Pendant Controlled Cranes*

For pendant controlled cranes, an isolating switch as mentioned in **14.4.3** shall be fitted.

16.4 Isolators for Auxiliary Circuits

All auxiliary connections, when required, shall be supplied from the live side of the main isolating switch and shall be controlled by separate isolating switches with cartridge fuse protection. If the supply voltage exceed 240 volts and if lamps are operated in series, double pole isolating switches shall be provided.

16.5 Interlocking

If the main isolating switch is combined with the crane protective panel, it shall be mechanically interlocked

with the door giving access to the panel and the incoming terminals shall be screened to prevent accidental contact when the door is open. When not so combined, a pair of pilot lamps or other device in duplicate with a red warning plate shall be provided to the covers of the protective gear, other panels and controllers not fitted with interlocking isolators. Access to the enclosures containing electrical equipments shall require use of a key or a tool to open them.

16.6 Isolating Switches for Down-Shop Conductors

Isolating switches for the down-shop conductors shall be provided by the purchaser at a suitable and accessible locations. The main and additional isolating switches should be so situated that any maintenance work or functional testing can be carried out without danger.

17 LIFTING MAGNET AND RELATED EQUIPMENTS

17.1 General

If required by the purchaser, the crane shall be fitted or provision shall be made to permit in the future fitting of lifting magnets, magnet control and protective gear.

17.2 Magnet

The type and size of magnet shall be decided based on the details given by the purchaser. Each magnet will be water tight and shall be provided with a water tight terminal box having the under mentioned features, however rectangular magnets are normally of fabricated construction type also can be used as follows.

a) integral construction with magnet casing,

b) a gland through which the magnet load is brought to the magnet terminals,

c) a cover which shall be easily removable without interfering with the magnet lead inlet,

d) adequate thickness of box and cover, and

e) non-linear type discharge resistor of adequate rating and the rectangular magnets are fabricated constructions and nice fabricated type of magnets.

17.3 Magnet Lead and Cable

The magnet lead and cable shall be flexible three core cables. If specified by the purchaser, the magnet lead shall be protected by rubber hose complying with the relevant Indian Standard. The magnet lead shall be so arranged that it does not become unduly slack or taut during normal operation of the crane. It should be so located that magnet cable does not foul with the rope. The use of sheaves and rollers for the cable should be avoided as far as possible. The magnet cable shall be rigidly attached to the bottom block by a suitable cable clamp at a point above magnet coupling.

17.4 Magnet Couplings

The type of magnet coupling shall be as agreed between the purchaser and the crane supplier. The coupling shall comply with the following requirements:

a) The coupling shall be of rugged construction.

b) At the moment of breaking, the contacts shall be enclosed by insulating material and earth connection shall break last.

c) Provision shall be made to fasten the coupling in the closed position.

d) The socket shall be connected to the supply and plug to the magnet or magnet lead.

17.5 Cable Drum

The magnet cable drum shall be as follows:

a) arranged so that magnet cable does not foul with the hoisting ropes,

b) such that the cable will become neither unduly taut, nor slack enough to touch the hoist ropes or get entangled, and

c) capable of accommodating and paying out the length of cable necessary for the magnet to reach its lowest position.

Cable drum when attached to the hoist drive, a disengagement device shall be provided. Where power is fed to the magnet by a brush and slip ring arrangement on the magnet cable drum, two brushes per slipring shall be provided and the rings shall have adequate clearance. The slip ring insulation shall be of non tracking material and the assembly shall be enclosed by an easily removable cover, oil-proof for indoor cranes and weather proof for out door cranes. A spare slipring complete with brush gear arrangement shall be provided if required by the purchaser.

17.6 Magnet Control and Protective Equipment

The magnet shall be controlled either by direct-on-

line control or potentiometer control as required by the purchaser. In both methods of control the magnet shall be demagnetized by current reversal.

In direct-on-line control, the magnet shall be energized by switching it across full mains voltage and discharge resistance shall be connected on switching 'OFF'.

The control shall be affected by means of a master controller and magnetic contactor panel.

17.7 Battery Back up System

If required by the purchaser necessary and adequate battery back up system shall be provided by the supplier. The rechargeable battery shall keep the magnet energized till the time the lifted load is brought to a safe location, in the case of power failure.

18 RESISTORS

18.1 General

Resistors shall be adequately protected to prevent accidental contact with live parts. The elements shall be protected against corrosion.

18.2 Rating

Resistors shall be rated such that the temperature does not exceed the limits specified in the relevant Indian Standard specification, during the operation of the crane under service condition. The resistance and current capacity of the resistors shall be computed according to the actual torque requirements of the motion served and not on the motor size which may be set by thermal requirements.

The effect of using plugging as a service brake shall be taken into account in determining the size of resistors. Resistors shall be rated according to the service conditions and the mechanical class of the crane and shall preferably be intermittent and short time rated. The rating of the resistors shall not be less than that given in the Table 15.

NOTE — For definitions of different intermittent rating, *see* Annex E.

Table 15 Rating of Resistors

Mechanism Class	Short Rating for Time Rated Resistors, *Min*
M1, M2	2
M3, M4, M5	5
M6, M7	10
M7, M8	To suit the service condition

18.3 Fittings

Resistors shall be enclosed in the well ventilated housings and, wherever necessary be fitted with suitable covers. They shall be mounted outside the main contactor compartment. Resistors shall be mounted on steel frames to withstand forces imposed by the crane under service conditions. They will be arranged in such a way that boxes can be easily replaced.

The connections to the resistor terminals should be accessible and adjustable. Resistor assemblies shall not impede the maintenance of the long travel drives or access to any part on the crane.

Resistor assemblies for each motion shall be stacked separately for the facility of inspection maintenance and safety.

18.4 Degree of Protection

Minimum degree of protection for the resistors shall be IP 11 or as specified by the purchaser.

19 LIMIT SWITCHES

The limit switches shall be of self-resetting type with in a reasonable distance travel in the opposite direction. In the case of changeover (memory) type limit switches resetting is achieved by striker moving in the opposite direction.

Snap action limit switches when actuated shall stop the motor and shall apply the brake or shall initiate dynamic braking if provided. The actuation of the limit switch shall trip the main incoming circuit breaker/ contactor and shall operate an audio and/or visual warning signal if required by the purchaser.

The manufacturer should fit one or more devices to the bridge of the crane to give warning of the approach to the danger or another crane. However, the purchaser can specify about the type of devices required for his crane so ordered. Devices using infra red lights, sound waves or limit/proximity switches may be used for this purpose. Limit switches shall be so arranged that they can be readily tested.

In the case where abnormally high lifts are required, arrangements shall be made by providing additional limit switches and by passing buttons as required by the purchaser. Fast or slow speeds may be provided for lifting heights as required by the purchaser.

Cams for strikers, when used for actuating limit switches, shall not damage the limit switches on over travel due

to impact or inertia.

20 CABLES AND CONDUCTORS

20.1 General

Cables used for crane wiring shall comply with relevant Indian Standard specifications. Unless otherwise agreed, only copper or aluminium cables shall be used for power wiring and only copper cables shall be used for control wiring. Single strand cables shall not be used where cable cross sectional area is more than 6 mm^2.

20.2 Minimum Size

Conductors for power wiring/control circuits to electric motors shall have a sectional area not less than the values given below of copper or equivalent material.

a) [2.5 mm^2 for Power] and [1.5 mm^2 for control wire] should be up to M5 sizes.

b) [4.0 mm^2 for Power] and [2.5 mm^2 for control wire] should be above M6 sizes.

20.3 Protection

All cables shall be adequately protected against mechanical damages as given below :

a) by running in conduits complying with relevant Indian Standards, trunking or on trays, or

b) by being clipped to the crane structure in a position where they are protected from mechanical damage, or

c) by being of armoured construction.

If cables are drawn into a steel tube, the tube shall be medium gauge welded or solid drawn or screw jointed. For outdoor cranes except where flexible unarmoured cables are essential, cables shall be either armoured or enclosed throughout their length in galvanized trunking or conduit. Taped and braided varnished cambric insulated cables shall not be used for outdoor cranes.

20.4 Current Rating

Rating of the cable, in the circuit related to mechanism Group 8, shall be not greater than the appropriate values given in the relevant Indian Standard specifications for continuous duty giving due considerations to ambient temperature, type of excess current, protection, grouping and disposition of cables and voltage drop. Cables in circuit related to mechanism group below M8 may be rated higher in accordance with Table 16.

20.5 Installation

The cable and wiring system for each motion shall be independent and common return shall be avoided. Main cables and controlled wiring shall be effectively separated. Cables shall be adequately secured to the main structure of the crane having due regard for the weight of the cable and the possibility of vibration. Cable runs shall not be installed in a place where they will impede the crane driver's view or hamper the movement of persons on the crane. The cables shall be placed so that they are easily accessible. Due consideration shall be given during the design of the crane to make adequate provision for cable runs and to avoid cable runs in locations where mechanical damage or high temperatures are likely to be experienced. The segregation of power and control cables shall be made as far as possible depending upon the space available on the crane and keeping or maintenance point of view.

Table 16 Operative Rating Cables
(*Clause* 20.4)

Mechanism Class	Stator Circuit Rating Multiplied By	Rotor and Resistor Rating Multiplied by
M1, M2	2.0	2.5
M3, M4, M5	1.7	2.0
M6, M7	1.4	1.5
M8	1.1	1.1

Where there is incidence of direct radiation of heat, the cables shall be protected by metallic shield. Where mineral insulated metal cables are subjected to the effects of high transient voltage they shall be suitably protected by the use of surge limiting devices. Cables remaining alive, when main isolator is opened, shall be separately installed and adequately protected. Adequate precaution shall be taken to prevent the ingress or collection of water or oil in any part of a conduit or trunking system.

20.6 Termination

Where trunking is used it shall extend into the electrical compartment or enclosed units. It shall be terminated as close as practicable to motors, collector gears and controllers. Junction boxes shall be rigidly fixed to the crane structure close to the end of the trunking. Conduiting systems shall be continuous to switch boxes

and conduit outlets. Cable tails shall be adequately insulated and mechanically protected.

21 AUXILIARY REQUIREMENTS

21.1 Lighting on the Crane

Necessary lighting arrangement for approaches and for carrying out maintenance work without danger shall be provided by the crane manufacturer in consultation with the purchaser. The nominal voltage of lighting circuits shall not exceed 250 V.

If hand lamp is provided it shall not be connected to a circuit exceeding 250V dc or 25V ac supply. In the case of an ac circuit hand lamp shall be fed through a double wound isolating transformer with some part of the secondary winding earthed. The primary winding of the transformer shall be controlled by a double pole switch. Fuses shall be provided in each pole of the primary circuit and one pole of each of the secondary circuits.

21.2 Cab Lighting

The cab and the panel room shall be provided with adequate lighting.

21.3 Under the Bridge Lighting

Under bridge lighting if required by the purchaser shall be mounted on shock absorbers and so installed that they can be serviced easily.

21.4 Other Provisions in the Cab

As required by the purchaser fans, air-conditioners or cab heating arrangements shall be provided by the crane manufacturer

21.5 Crane Warning Signals

If required by the purchaser,the crane shall be equipped with warning lights on both sides of the crane and/or sound signals to indicate approach of the crane or hook. Each warning light fitting shall contain two electric bulbs connected in parallel.

Each fitting shall be provided with an anti-vibration mounting and shall be accessible. They shall not interfere with the driver's vision and shall be readily visible to the concern persons.

22 CONDUCTORS AND CURRENT COLLECTORS

22.1 General

The type of current collecting system for long travel and cross travel motion shall be provided as required by the purchaser. Bare conductors used for the purpose of picking up current shall be placed out of reach or protected to prevent accidental contact by persons operating, maintaining or inspecting the crane. No bare conductors should be placed in the inner middle of grinder all types of conductors system should be accessible for maintenance and replacement. The protection may be in the form of local guards fitted on the crane.

22.2 Bare Copper Wires

Bare copper wires when used as conductors shall comply with IS 282. Wires smaller than 25 mm^2 of equivalent copper area shall not be used. Intermediate supporting insulators for the copper wires shall prevent wires leaving them under any condition. Adequate tensioning devices shall be installed at the wire ends and there shall be no possibility of adjacent wires coming into contact.

22.3 Trailing Cable Arrangement

In the trailing cable arrangement the conductors shall be insulated flexible single or multiple core cables as specified in 19 with permanent termination on the fixed part and moving part. The flexible trailing cables shall have sufficient length and shall be supported on trolley with clamps. The trolley shall run freely on a guide without undue stresses or wear on suspended cables and cable trolleys should have four wheels fitted with antifriction bearings.

22.4 Rating

Unless otherwise specified the maximum current density shall not exceed 0.42 A/mm^2 for rolled steel sections, 1.2 A/mm^2 for aluminium sections and 2.5 A/mm^2 for copper sections. The gap between the current collector and adjacent live or earth part shall not be less than 50 mm.

22.5 Down-Shop Lead Arrangement (Long Travel Current Collecting System)

22.5.1 *General*

Down shop lead arrangement using copper, aluminium or steel sections with or without shrouding or by using flexible trailing cable arrangement may be used. Use of shrouded conductors, where possible is recommended.

22.5.2 *Conductors*

Current collecting system shall be provided either by the purchaser or by the crane manufacturer as agreed by them.

Cranes operating on bare conductors shall be equipped

with adequate guards to prevent ropes or suspended load coming in contact with the live conductors due to swing of the hook block. Down-shop conductors also shall be screened to prevent contact while handling long lengths of conducting materials from floor.

22.5.3 *Current Collectors*

Unless otherwise agreed to, all collector assembly shall be supplied by the crane manufacturer. The purchaser shall furnish relevant details depending upon the manufacturers scope of work. Collector rollers or shoes shall be so designed as to avoid sparking and shall be easily replaceable. Collector assembly shall be mounted on a rigid structure on the crane bridge. Necessary safe and convenient access shall be provided for maintenance or replacement of the collectors.

22.6 Cross Travel Current Collecting System

22.6.1 *General*

Cross travel current collecting system shall be with bare conductors or with shrouded conductors or with trailing cable arrangement. The collection system shall be provided by the manufacturer.

22.6.2 *Conductors*

Cross travel conductors for the main crab shall be mounted on the main bridge platform and not inside the main girders. Conductors for auxiliary crabs shall be mounted suitably above the level of auxiliary crab rails. Cross travel conductors shall be arranged so that they are all accessible for maintenance from at least one side along the whole length. Bare conductors mounted on the bridge adjacent to a walk way along the bridge shall be completely screened from the walkway.

22.6.3 *Collector Assembly*

Collector assembly shall be rigidly mounted on the crab and shall be provided with reasonable accessibility to all parts for maintenance purpose.

23 EARTHING

23.1 General

The crane structure, motor frames, and metal cases of all electrical equipment including metal conduit or cable guards shall be effectively connected to earth complying with *Indian Electricity Rules* (*see* IS 3043). A flexible metallic tube or duct may not form an effective earth connection. The crane wheels shall not be used as means of earthing.

Where the crane is connected to the supply by flexible cord or flexible cable, the crane shall be connected to earth by means of a separate earthing conductor enclosed with the current carrying conductors.

Travelling cranes connected to the supply through collectors shall be effectively earthed through a fourth lead or through a set of collectors sliding on the gantry rail with reference to IS 3043.

The purchaser shall arrange for the earthing of the gantry and /or the long travel earth conductor.

23.2 Control Circuit Earthing

One end of the secondary winding of control circuit transformer shall be earthed. One end of the coil of all relays and contactors shall be connected to earth side of the control circuit supply and this connection shall not be interrupted by any fuse or contact.

In the case of dc control circuits one pole of the rectifier shall be earthed.

23.3 Magnet Earthing

The magnet frame shall be bonded to the crab by the earth connection via the magnet lead, the magnet coupling, the magnet cable and an extra slip-ring on the cable drum.

24 ELECTRICAL EQUIPMENTS LOCATED ON THE CRANE BRIDGE

24.1 General

Electrical equipments mounted on bridge platform shall be enclosed in suitable enclosure with provision for easy access to the parts inside. The units shall not impede the maintenance of the long travel drives. The control panels or units shall be so spaced that efficient maintenance is possible. They shall withstand the mechanical forces imposed by the crane under service conditions. For cranes working in open yard, electrical equipments shall be of weather-proof construction for the duty. Control panels and other electrical equipment shall be so located that there is no chance for oil or grease falling on them. The thorough fare between any portion of the crane and the exit platform shall not be impeded by any control unit. However, also refer the below given Table 17 for information may suitably used for the enclosers where discussed.

24.2 Identification of Circuits

All switches, fuses, panels, controllers, resistors connectors and other electrical elements of controller

Table 17 Information for Enclosures

Equipment	In-door	Out-door
Control panel	IP 54 (with double door)	IP 55 (with double door)
Limit switches	IP 54	IP 55
Resistances	IP 11	IP 33
Motor	IP 54 (with cover)	IP 55 (with cover)

panels shall be adequately labelled or marked by furnishing functional nomenclature to facilitate identification of the circuit. All main and control wires and conductors shall be ferruled and numbered at both ends as per drawing for quick identification. All equipment terminals shall be numbered and tagged.

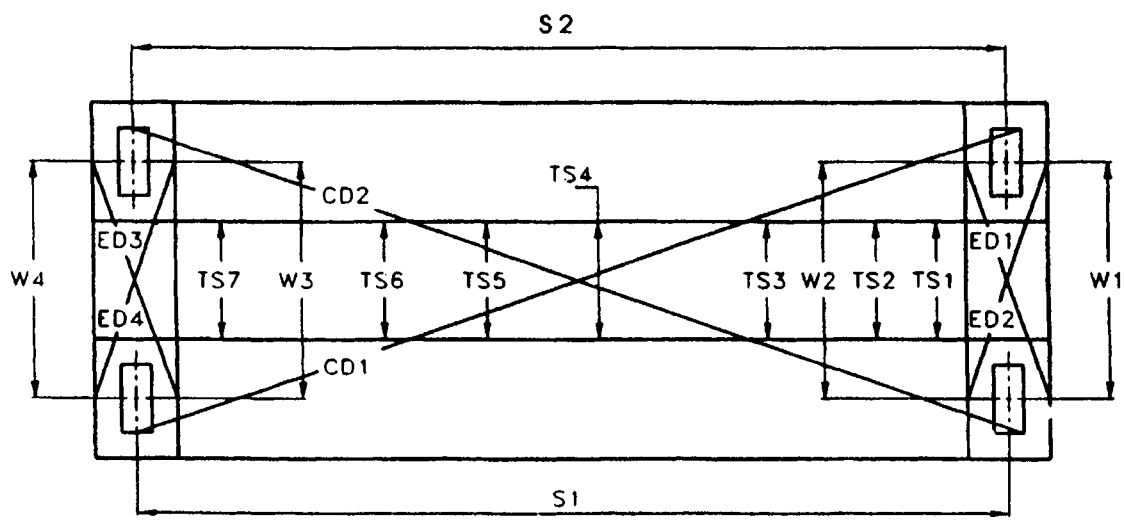
25 DRAWINGS

A wiring diagram of the crane shall be supplied by the manufacturer. The diagram shall give the rating of each motors, the cable sizes and such other information which will facilitate inspection and maintenance of the crane. All electrical elements shall be designated by functional nomenclature and numbered for identification. All main and control wires and terminals shall be numbered to facilitate wiring and identification while maintaining. A schematic diagram shall also be supplied for contactor controlled cranes along with the list of parts used. In addition to the drawings the following drawings and documents may also be provided as given below:

a) External termination drawings and cable schedule, and

b) GA drawings of all electrical items.

CRANE INSPECTION PROCEDURE



CRANE DIMENSIONS

DATA	W1	W2	W3	W4	ED1	ED2	ED3	ED4	S1	S2	CD1	CD2
SPECIFICATION												
ACTUAL												
TOLERANCE												

FIG. 6 CRANE DIMENSIONS (*Continued*)

DATA	TS1	TS2	TS3	TS4	TS5	TS6	TS7	REMARK
SPECIFICATION								
ACTUAL								
TOLERANCE								

CRANE LOCATION :

CAPACITY AND TYPE :

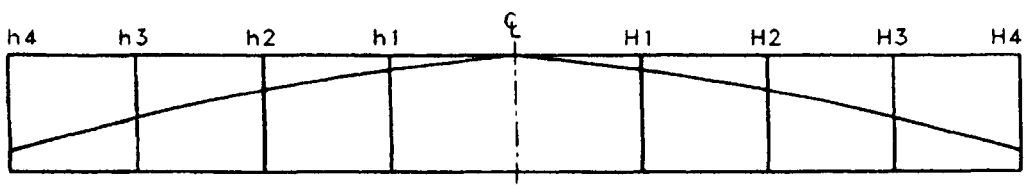
CRANE MANUFACTURER :

ORDER NUMBER :

DATE OF INSPECTION :

PLACE OF INSPECTION :

FIG. 6 CRANE DIMENSIONS



SPACING 3.5

USE WATER LEVEL TO TAKE READING

GIRDER	h4	h3	h2	h1	L	H1	H2	H3	H4
DRIVING									
TRAILING									

a) DEFLECTION DUE TO DEAD LOAD OF BRIDGE GIRDER :

b) DEFLECTION DUE TO TROLLEY WEIGHT :

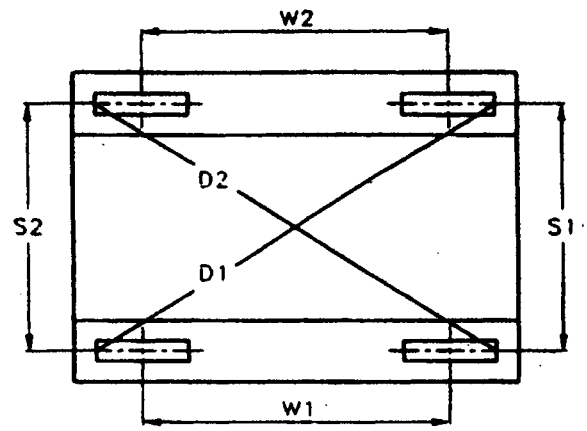
c) DEFLECTION DUE TO RATED LOAD :

d) ACTUAL CAMBER :

e) ACTUAL DEFLECTION

REMARKS :

FIG. 7 BRIDGE CAMBER



DATA	W1	W2	S1	S2	D1	D2	REMARKS
SPECIFICATION							
ACTUAL							
TOLERANCE							

REMARKS :

FIG. 8 TROLLEY DIMENSIONS

SECTION 4 INSPECTION AND TESTING

26 INSPECTION PROCEDURE

26.1 General

If required by purchaser and specified in the contract, the purchaser or his authorised representative shall have access to the manufacturer's works at all resonable times for the purpose of witnessing the manufacturer, inspection and testing of all products concerned and /or the complete crane.

Any work found defective or which is not in accordance with the drawings or of the terms of this code and/or contract may be rejected by the inspector (*see* Fig. 6, 7 and 8).

26.2 Test at Manufacturer's Works

All electrical and mechanical equipment shall be tested in accordance with the appropriate Indian Standard at either the crane maker's or equipment manufacturer's works and test certificates provided, if required by the purchaser.

If required by the purchaser and specified in the contract, the crane shall be tested at manufacturer's works under full load and 25 percent overload of hoisting and cross traverse motions. Travelling gear may be run light to check shaft and gear alignments. If load test is carried out all the manufacturer's premises, it shall be carried out at the purchaser's premises.

Any test required by the purchaser beyond those called for in the appropriate Indian Standard shall be subject to mutual agreement and shall be carried out at the purchaser's expense.

26.3 Trolley Movement Over Bridge Girder

a) Whether all the 4 wheels are in contact with the rails at all places .....

26.3.1

Quality of Alignment of Geared Couplings	*Axial Misalignment* (in mm)	*Angular Misalignment* (in degree)
a) Main hoist	.....	.....
b) Auxiliary hoist	.....	.....
c) Cross traverse	.....	.....
d) Long travel	.....	.....

26.3.2 *Condition of Cable Trolleys*

a) Are they provided with ball bearings: ....

b) Are they fitted with single flanged wheels: ....

c) How many wheels per trolley: ....

d) Number of trolleys: ....

26.3.3 *Performance of Mechanisms (Each Mechanism should be Run for 30 min Continuously for this Test)*

a) *Long travel* (No load running on sleepers or on Test Bench)

i) Noise level from gear box .....

ii) Oil leakage through input and output shaft .....

iii) Linear speed of wheel treated at full speed .....

iv) Hardness of gears/ pinion .....

v) Material of gears/ pinion .....

b) *Main hoist*

i) Noise level from gear box .....

ii) Oil leakage through shafts ....

iii) Surface speed of wire rope drum .....

iv) Hardness of gears/pinion .....

v) Material of gears/pinion .....

c) *Auxiliary hoist*

i) Noise level from gear box .....

ii) Oil leakage through shafts .....

iii) Surface speed of wire rope drum .....

iv) Hardness of gears/pinion .....

v) Material of gears/pinion .....

d) *Cross traverse*

i) Noise level from gear box .....

ii) Oil leakage .....

iii) Linear speed .....

iv) Hardness of gears/pinion .....

v) Material of gears/pinion .....

26.3.4 *Hardness*

a) Long travel wheels .....

b) Cross traverse wheels .....

c) Permissible values .....

26.3.5 *Material of Wheel for LT, CT* .....

26.3.6 *Hardened* .....
(*Process of hardening*)

26.3.7

Painting	*Actual*	*As per Specification*
a) Prime coat	.....	.....
b) Finishing first coat	.....	.....
c) Second coat	.....	.....

26.3.8

Bolt Holes Alignment (Tolerance level of bolts and holes)	*Fit bolts (Reamed holes)*
a) Bridge girder splice	.....
b) Gantry leg spice	.....
c) End carriage splice	.....
d) End connection (End carriage and girder)	.....

26.3.9 *Idle Running and Speed of the Motor*

a) Main hoist .....

b) Auxiliary hoist .....

c) Cross traverse .....

d) Long travel .....

26.3.10 *Electrical*

Motors (idle running and measuring the no load and full load current) :

a) Main hoist .....

b) Auxiliary hoist .....

c) Cross traverse .....

d) Long travel .....

(variable speeds of different motion under no

load and load condition)

	Main Hoist	*Auxiliary Hoist*	*Cross Traverse*	*Long Travel*
I notch	.....	.....	.....	.....
II notch	.....	.....	.....	.....
III notch	.....	.....	.....	.....
IV notch	.....	.....	.....	.....
V notch	.....	.....	.....	.....
Rated speed as per specification	.....	.....	.....	.....

26.3.11

Control Panel	*As per Drawing*	*Actual* (IP 54 or IP55)
a) Size	.....	.....
b) Power contractor size and rating	.....	.....
c) Rotor contractor size and rating	.....	.....
d) Terminal blocks size	.....	.....
e) Types of wiring	.....	.....
f) Cable (aluminium/ copper)	.....	.....
g) Spacing of the contractors and timers	.....	.....
h) Multi hinged doors	.....	.....
j) Type of beeding provided	.....	.....

26.3.12 *Wiring*

	Crane	*Trolley*	*Cabin*
a) Any defect noticed ?	.....	.....	.....
b) What type of wiring ?	.....	.....	.....
c) Rectification needed ?	.....	.....	.....
d) Whether cabin wiring completed ?	.....	.....	.....
e) Are the different motions as per wiring diagram ?	.....	.....	.....

26.3.13

a) Is plugging and reversing functioning ?

b) Is creeping functioning ?

c) Is counter torque lowering working satisfactorily ?

d) Is zero speed monitor functioning ?

26.3.14

Resistors	*Main Hoist*	*Auxiliary Hoist*	*Cross Traverse*	*Long Travel*
a) Rating and value of resistance in each step	.....	.....	.....	.....
b) What is the type of resistor used	.....	.....	.....	.....
c) Is resistor as per specification ?	.....	.....	.....	.....
d) Lugs to be provided in the terminals	.....	.....	.....	.....
e) Heating condition during no load and full load testing	.....	.....	.....	.....

26.3.15 *Check the Functioning and Observe*

	Main Hoist	*Auxiliary Hoist*	*Cross Traverse*	*Long Travel*
a) Contractors	.....	.....	.....	.....
b) Timers	.....	.....	.....	.....
c) Limit switches	.....	.....	.....	.....
d) Overload protection	.....	.....	.....	.....
e) Controllers	.....	.....	.....	.....

26.3.16 *Check the Functioning of Accessories*

a) Ceiling fan .....

b) Warning bell .....

c) Underbridge lighting .....

d) Operator's seat .....

26.3.17 *Insulation Tests*

After erection but before the crane is connected to the supply, the insulation of the electrical equipment shall be tested by a suitable instrument and any defects revealed shall be rectified. The voltage required for the insulation resistance test shall be d.c. voltage not less than twice the rated voltage of the system concerned and all phase shall be checked for each crane motion or system. Any reading less than 0.5 M ohm obtained with an insulation resistance tester shall be verified. The wiring under test shall be subdivided until a reading higher than 0.5 M ohm is obtained. Failure to obtain higher reading shows an unsatisfactory state of the insulation and hence shall be rectified.

NOTE — A reading below 0.5 M ohm obtained with such a tester may indicate that unduly low proportion of the prescribed test voltage is in fact being applied.

If an installation has been subdivided for test purposes each sub-division shall meet the requirements. The insulation resistance of each wiring circuit exclusive of connected apparatus shall be not less than 2 M ohm. If necessary, it shall be permissible to disconnect individual items of equipment making this test.

26.3.18 *Test Certificate*

If specified by the Government of the State in which the crane is to be installed, the tests shall be carried out in the presence of the competent authority appointed, by the concerned industrial safety department of the government. The crane shall be put in use only after clearance and acceptance certificate is issued by the competent authority. The purchaser shall arrange to ensure presence of the competent authority at the time of testing.

The manufacturer shall issue a test certificate clearly indicating the tests carried out and results obtained.

27 GENERAL REMARKS

27.1 Welding Inspection Procedures

27.1.1 *Visual Examination*

Refer Table 18 for verification.

27.1.2 *Proforma for Welding Profiles Certificate* (*see Table* 19)

27.1.3

a) *Radiographic procedure*

i) Radiographic shall be made by either X-ray or isotope radiation methods.

Table 18 Certificate

Sl No.	Condition	Acceptable/Not Acceptable	Reason for Not Acceptable
(1)	(2)	(3)	(4)
i)	The weld has no cracks		
ii)	Complete fusion exists between adjacent layers of weld metal, and between weld metal and base metal		
iii)	All crates are filled to full cross section of the weld		
iv)	Weld profiles are in accordance with Fig. 9		
v)	Permissible frequency and size of piping porosity in fillet welds shall be limited as follows:		
	a) For primary welds not more than 1 mm pore in each 102 mm length and no larger in diameter than 2.4 mm		
	b) For secondary welds the sum of the diameters of piping porosity shall not exceed 9.5 mm in any linear mm of weld and shall not exceed 19 mm in any 305 mm length of weld		
vi)	The actual size of a portion of continuous fillet weld, 9.5mm or larger, can be under the normal required fillet weld size by 1.6 mm without correction, provided that the under size portion does not exceed 10 percent of the weld length		
vii)	Primary groove welds must have no piping porosity		

Table 19 Certificate
(*Clause* 27.1.2)

Sl No.	Condition	Acceptable/ Not Acceptable	Remarks
(1)	(2)	(3)	(4)
i)	The faces of the fillet welds (a) Convex (b) Flat (c) Slightly concave (concavity must not exceed the sum of 0.1s + 1mm where is the actual size of the fillet in mm)		
ii)	a) Groove welds must be free of the discontinuities. b) In case of butt and corner joints, the reinforcement height R, must not exceed 3 mm f or metal thickness of 51mm and under 5mm for metal thickness over 51 mm		
iii)	Where the surface of butt joints are required to be flush, the thickness of the thinner base metal or weld metal shall not be reduced by more than 0.8 mm		
iv)	Under cut depth shall not exceed 0.8 mm or 7 percent of the base metal thickness		
v)	Welds shall be free from overlap		

ii) The quality level of inspection for radiographs shall be 2.2 T, except that the dia of the 2T penetrate meter hold need not be less than 1.6 mm for X-ray or 2.4 mm for gamma ray radiographs.

iii) Radiographs shall have a H and D density between 1.5 and 3.5.

iv) Two or more penetrate meters shall be used for each radiographs on a film 254 or more in length. Only one penetrate meter need be used for radiographs on film less than 254 mm in length.

v) Radiographs shall be made with a single source of radiation approximately centred with respect to the length and width of the area being examined. The distance from radiation source to the film shall not be less than 7 times the maximum thickness of weld being examined, and the rays shall not penetrate the weld at an angle greater than 26.5°. From a line perpendicular to the weld surface. The film, during expose, shall be as close as possible to the surface of the weld opposite to the source of radiation.

b) *Acceptabilty of Radiographic Welds*

i) Welds subject to radiographic examination shall first be visually examined to check the cracks and welding profiles.

ii) The greater dimensions of the porosity or fusion type discontinuity indications that are 1.6 mm or larger shall not exceed the size.

iii) Discontinuities meeting requirements of 1 and 2 and having a greatest dimensions of less than 1.6 mm are nevertheless not acceptable if the sum of their greatest dimensions 9.5 mm in any linear 25 mm of weld.

iv) The limitations for 38 mm groove weld effective throat shall apply to all welds with larger effective throats.

v) A recommended form for reporting the results of radiographic examination is shown as per format attached (*see* Fig. 9).

27.1.4 *Ultrasonic Test, Magnetic Particle and Liquid Penetrant Tests as per ASTM E164, ASTM E709 and ASTM E165*

a) Ultrasonic examination of welds,

b) Ultrasonic testing procedures acceptance criteria and reports,

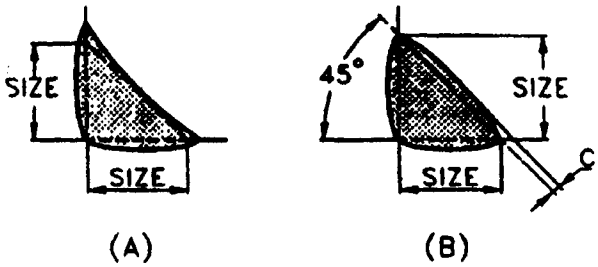
c) Magnetic particle examination of welds A, and

d) Liquid penetrant examination of welds. The recommended forms for reporting the results of the above tests as shown in the formats attached.

27.1.5 *Repair and Correction of Discontinuities*

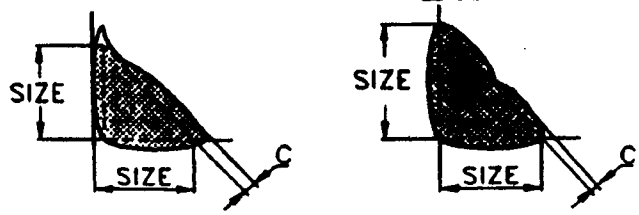
a) *Overlap or excessive convexity* — Remove excess weld metal.

b) *Excessive concavity of weld or crater and under size welds* — Prepare surfaces and deposit additional weld metal. All slag shall

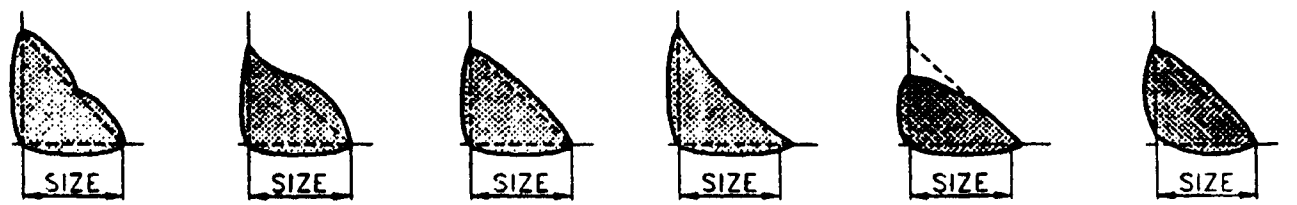


(A) (B)

DESIRABLE FILLET WELD PROFILES



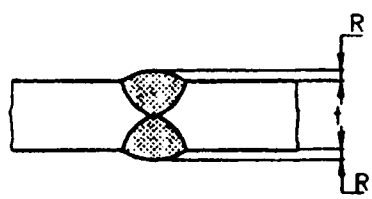
(C) DESIRABLE FILLET WELD PROFILES



INSUFFICIENT THROAT | EXCESSIVE CONVEXITY | EXCESSIVE UNDERCUT | OVERLAP | INSUFFICIENT LEG | INCOMPLETE FUSION

(D) UNACCEPTABLE FILLET WELD PROFILES

SMOOTH WASH UNDERCUT SHALL NOT EXCEED 0.80mm OR A MAX. OF 0.07t



METAL THICKNESS	WELD REINFORCEMENT
t(mm)	R(mm)
50mm OR LESS	3.18mm
OVER 50mm	4.77mm

(E) ACCEPTABLE BUTT JOINT WELD PROFILE

EXCESSIVE CONVEXITY | INSUFFICIENT THROAT | EXCESSIVE UNDERCUT | OVERLAP

WELD SIZE TOLERANCES	
WELD SIZE IN (mm)	WELD SIZE TOLERANCE IN (mm)
UNDER 10mm	−0 +1.6
10mm OR LARGER	−1.6 +3.18

FIG. 9 ACCEPTABLE AND UNACCEPTABLE WELD PROFILES

be removed and the adjacent base metal shall be cleaned before additional welding.

c) *Cracks in weld or base metal* — Determine the extent of the cracks by dye penetrant magnetic particle inspection or other suitable means. Remove the crack and adjacent sound metal for a 51 mm length beyond each end of the crack and then reweld.

d) *Under cutting* — Under cutting may be repaired by grinding and blending or by welding. Grinding should be performed with a pencil type grinder. Blending shall be done with a slope not to exceed 1 in 3 on plates of 13 mm thickness and above, up to 7 percent reduction of base material thickness is permitted. When undercut is to be repaired by welding, prepare the surfaces and then deposit additional weld metal.

27.1.6 *Base Material Repairs*

a) *Defects in edges of plate* — If a defect is found in a plate edge that excess the limits, shall be removed and repaired.

b) *Arc strikes and temporary attachment* — Areas : Arc strikes or severed temporary welds in critial locations, must be ground smooth to ensure that no abrupt change in section exists.

c) *Removal of defective areas* — The removal of weld metal or portions of the base metal may be done by machining, grinding, chipping, oxygen gouging or air carbon arc gouging. It shall be done in such a manner that the remaining weld metal or base metal is not nicked or undercut.

Unacceptable portions of the weld shall be removed without substantial removal of the base metal.

Additional weld metal,to compensate for any deficiency in size, shall be deposited using low hydrogen eloctrodes.

d) *Distortion and camber* — Members distorted by welding shall be straightened by mechanical means or by carefully supervised application of a limited amount of localised heat. The temperature of heated areas, as measured by approved methods shall be limited to that imposed by the materials exposed to the heat, but it shall not exeed 590°C for quenched-and tempered steel nor 890°C for other steel.

e) *Correction of improperly fitted and welded members* — If a weld is found to be unacceptable after additional work has rendered it inaccessible, or new condition make correction of the unacceptable weld dangerous or ineffetual, or original conditions shall be resorted by removing welds or both, before the corrections are made.

28 TESTING

28.1 Preliminary Tests

The preliminary tests shall be done before the hoist block is reeved. Test the various methods as follows. Close the runway, disconnect the switch, the main crane disconnect switch, and the individual motor and accessory switches in that order.

28.1.1 *Hoist (Main Hoist and Auxiliary Hoist)*

a) Place master switch in 1st point 'hoist' position.

b) Observe the contactor for proper sequence and direction of hoist drum rotation. If operating correctly the speed may be gradually increased.

c) If hoist contactor and rotation is not correct, shut off power, reverse two leads on the main line collectors or on the hoist motion (whichever is incorrect), to obtain the correct phasing. Restore power the repeat step (a) and (b).

d) After checking hoisting, return master switch to neutral position and observe braking action, readjust if needed.

e) Place master switch in 'lower' 1st point and observe if correct motion and contactor sequence occurs.

f) Reset hoist timers, if needed.

g) Speed points shall be for accelerating only and shall not be used for running any distance. Maximum time for acceleration is 15 s, unless special equipment is provided. If held any longer, resistor damage may occur.

h) The above steps (a) to (g) shall be repeated for auxiliary hoist same as main hoist.

28.1.2 *Cross Travel Motion*

a) Place master switch in 1 point 'Trolley travel' position.

b) Observe contactor sequence and direction of travel through full range of master switch.

Reverse phasing, if necessary.

c) Allow trolley to move entire length of bridge span, are fully watching alignment of trolley collector pole and bridge conductors and also watching for any interference with building and building equipment. Do not run trolley into end stops.

d) Adjust end limit switch trip.

e) Reverse master switch and repeat (a) to (d).

f) Reset trolley timers, if needed.

28.1.3 *Bridge Motion (Long Travel)*

a) Place master switch in 1st point 'Trolley travel' position.

b) Observe contactor sequence and direction of travel through full range of master switch. Reverse phasing, if necessary.

c) Allow trolley to move entire length of bridge span, are fully watching alignment of trolley collector pole and bridge conductors and also watching for any interference with building and building equipment. Do not run trolley into end stops.

d) Adjust end limit switch trip.

e) Reverse master switch and repeat (a) to (d).

f) Reset trolley timers, if needed.

28.1.4 *Check all Accessories for Proper Function*

28.2 No-Load Test

28.2.1 *After Reeving the Hoist, Test the Operation of the Hoist Limit Switches as follows*

a) Raise empty blocks to within about 500 mm of its upper position and stop.

b) Raise the empty block at the lowest control speed until the limit switch trips and stops the hoisting motion. During this operation watch for proper alignment between load block and limit switch trip.

c) Check that block stops at correct height as shown on drawings. Adjust limit switch, if necessary.

d) Lower block to 1.5 m.

e) Raise block at about half speed.

f) Check for adequate clearance between block and trolley frame (or upper sheaves).

g) Repeat points (d), (e) and (f) with block being raised at full speed.

28.2.2 *If Crane is Equipped with a Lower Limit Switch, Proceed as follows*

a) Lower the empty block until one wrap of rope remains on each end of the drum.

b) Set lower limit switch to trip at this point (or any higher elevation).

28.2.3 Never lower block beyond the point at which one wrap remains at each end of the drum.

28.3 Load Test

After the no-load running test has been completed, the crane should be tested with loads in the following manner:

a) Raise a load equal to about 5 percent of the rated load not higher than required to clear its supports and stop adjust brake, if necessary. Raise load about 1 m above its supports and stop. Lower the load about 300 mm and stop. Check drift of load during stopping.

If load drifts, brakes are not in proper adjustment and should be corrected. Repeat this operation until proper adjustment of brakes is obtained. Lower load carefully back to its supports.

b) Load the hoist motion with 125 percent of rated capacity and follow the same procedure as mentioned in (a).

i) Then hoist the load high enough to clear all obstructions but not higher than necessary. Move trolley across the entire span of bridge. Transport the test load by means of the bridge for full length of the runway in one direction with the trolley at the extreme right hand end of the crane, and in the other direction with the trolley at the extreme left hand end of the crane.

ii) Measure the deflection when the trolley with test load is at the middle of the girder and at extreme end of the girder. Check whether the deflection is within the allowable limit.

iii) Measure the 'No-Load'and 'Full Load' current of the motor and verify whether it is as per the recommendations of motor manufacturers.

Check the resistors in the circuit whether any over-heating of the element occurs.

iv) If separate creep speed control is provided it should be run for check-out over a distance of about 500 mm.

v) Check overload relays for proper function.

REPORT OF RADIOGRAPHIC EXAMINATION OF WELDS

Project .....

Quality requirements — Section No. .....

Reported to .....

WELD LOCATION AND IDENTIFICATION SKETCH

Technique source .....
Film to source .....
Exposure time .....
Screens .....
Film type .....

(Describe length, width and thickness of all joints radiographed)

Date	Weld Identification	Area	Interpretation		Repairs		Remarks
			Accept	Reject	Accept	Reject	

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AWS Specification D 14.1

Radiographer(s) .....

Interpreter .....

Test date .....

Manufacturer or Contractor .....

Authorized by .....

Date .....

REPORT OF MAGNETIC PARTICLE EXAMINATION OF WELDS

Project .....

Quality requirements — Section No. .....

Reported to .....

WELD LOCATION AND IDENTIFICATION SKETCH

Date	Weld Identification	Area	Interpretation		Repairs		Remarks
			Accept	Reject	Accept	Reject	

We, the undersigned, certify that the statements in this record are correct and that the welds were prepared and tested in accordance with the requirements of AWS Specification D 14.1

Inspector .....

Test date .....

Manufacturer or Contractor .....

Authorized by .....

Date .....

Method of Inspection :

1. Dry 2. Wet 3. Residual 4. Continuous 5. ac 6. dc 7. Half-wave

DYE PENETRANT INSPECTION REPORT

Customer ..... Date .....

Order No. ..... Material .....

Drawing No. ..... Specification .....

Places	Description	Comments

Soak time .....

The above parts have been carefully tested with dye penetrant. This inspection is limited to defects of the type which can normally be located with the dye penetrant inspection method.

ANNEX A
(*Clause* 4.1.1)

INFORMATION TO BE SUPPLIED WITH ENQUIRY

The purchaser shall supply the following information with the enquiry or order. Where the purhaser is unable to fill any particular portion or he wants crane manufacturer to specify, the requirement shall be made the subject of agreement between the purchaser and the manufacturer to specify, the requirement shall be made subject of agreement between the purhaser and the manufacturer.

A-1 GENERAL

1) Crane to be installed at ..... Bay/Department .....

2) No. of cranes .....

3) Capacity

Main Hoist ..... tonnes
Auxiliary Hoist ..... tonnes

4) Type of crane .....

5) Span (centre to centre of rails) ..... mm

6) Location : Indoor/Outdoor/Both .....

7) Nature of load .....

NOTE — In the case of magnet and grabbing cranes, the specification and physical condition of the material to be handled shall be given.

8) Altitude of the place : (Where the crane is to be installed)

A-2 CLASSIFICATION

A-2.1 Where detail information is available of the operations and of the individual loads to be carried at each stage of the operations.

Utilization:

Main hoist — Average lift ... M; No. of lifts/h ....

Aux hoist — Average lift ... M; No. of lifts/h .....

Traverse — Average ..... M; No. of move/h ..... movement

Travel — Average ..... M; No. of move/h ..... movement

Crane — Operating h/day .....
Operating h/month .....
Operating h/year .....

Loads — Actual loads, if known .....
or percent lifts with approximately full load

Percent of lifts with approximately 75 percent load .... including

Percent of lifts with approximately 50 percent load .... lifting

Percent of lifts with approximately 25 percent load .... attachment

Weight of lifting attachment .....

A-2.2 Where insufficient information is available of the operations, classification shall be as follows:

Main hoist .....

Auxiliary hoist .....

Traverse .....

Travel .....

Crane structure .....

A-3 CRANE PERFORMANCE

A-3.1 Speed of Operation

	Full Speed M/Min	Creep Speed M/Min
Main hoist	.....	.....
Auxiliary hoist	.....	.....
Traverse	.....	.....
Travel	.....	.....

A-3.2 Vertical Movement of Hook

Above floor ..... M
Below floor ..... M

A-4 COMPONENT DETAILS

A-4.1 Rope Drum Details

a) Material .....

b) Diameter .....

c) Length .....

d) Flange/Flangeless .....

A-4.2 Rope Details	Main Hoist	Aux Hoist
a) Rope construction	.....	.....
b) Tensile strength	.....	.....
c) Diameter of the rope	.....	.....
d) Length of the rope	.....	.....
e) No. of falls	.....	.....

A-4.3 Sheaves Details	Main Hoist	Aux Hoist
a) Material	.....	.....
b) Diameter of the sheaves (Main)	.....	.....
c) Diameter of the sheaves (Equaliser)	.....	.....
d) Type of guards provided	.....	.....

A-4.4 Coupling Details (Between Motor and Gear Box)	Main Hoist	Aux Hoist
a) Type of coupling	.....	.....
b) Torque rating	.....	.....
c) Size	.....	.....

A-4.4.1 Coupling Details (Between Gear Box and Rope Drum)	Main Hoist	Aux Hoist
a) Type of coupling	.....	.....
b) Torque rating	.....	.....
c) Size	.....	.....

A-4.4.2 Coupling Details (Between Gear Box and Wheels)	Main Hoist	Aux Hoist
a) Type of coupling	.....	.....
b) Torque rating	.....	.....
c) Size	.....	.....

A-4.5 Gear Box Details	M.H.	A.H.	C.T.	L.T.
a) Type of mounting (Horizontal / Vertical)	.....	.....	.....	.....
b) Classification	.....	.....	.....	.....
c) Total No. of reduction	.....	.....	.....	.....
d) Reduction ratio	.....	.....	.....	.....
e) Type of lubrication (grease/splash/pump lubrication)	.....	.....	.....	.....
f) Hardness (BHN) (Gear/Pinion)	.....	.....	.....	.....
g) Materials — Gears/ Pinion	.....	.....	.....	.....
h) Casting/Fabricated	.....	.....	.....	.....
k) Type and size of bearings in each stage	.....	.....	.....	.....
m) kW rating	.....	.....	.....	.....

A-4.6 Type of Drive Arrangement (Vertical/ Horizontal)	M.H.	A.H.	C.T.	L.T.

A-4.7 Wheel Details	Long Travel	Cross Travel
a) Material	.....	.....
b) Hardness	.....	.....
c) Depth of hardness	.....	.....
d) Diameter	.....	.....
e) Process of hardening	.....	.....

A-4.8 Brakes	M.H.	A.H.	C.T.	L.T.
a) Diameter of the brake	.....	.....	.....	...
b) Torque rating	.....	.....	.....	.....
c) Type of brake (ac/dc/Thrustor)	.....	.....	.....	.....

A-4.9 Type of Lifting Hooks (C type/ Rams horn)	Main Hoist	Aux. Hoist
Safety latch on hook required /not required	.....	.....
Locking device on : swiveling hook required /not required	.....	.....

A-4.10 Type of Buffers Required (Spring type/Hydraulic)

For crab .....

For long travel .....

A-4.11 Type of Bridge Girder Required

a) Size .....

b) Type of connection to the end carriage .....

c) Width .....

d) Length .....

A-4.12 Type of Platforms Required on Bridge

Position of access points .....

Emergency escape .....

Type of access platform to cabin .....

Width of platforms .....

A-4.13 Type of Operator's Cabin :

Fixed/Moving and open/glazed

Location on bridge fixed if, ...

Type of fire extinguisher provided .....

Seating arrangement .....

Position of controllers .....

A-5 ELECTRICAL DETAILS

A-5.1 Power Supply at the Crane Long Travel Collectors

ac or dc Voltage ..... (nominal) + ... percent

No. of phases ..... frequency Hz + ... percent

No. of conductors .....

Neutral: Existing/Not existing .....

Type of earthing provided .....

Long travel conductors .....

a) Length .....

b) Size .....

Long travel collectors by : Purchaser/ Manufacturer

A-5.2 Controls

Whether control is from cabin/pendant/ non-conductive

a) Remote control .....

b) Cabin operated .....

c) Pendant : Suspended from crab/fixed point on bridge

d) Type of pendant .....

e) Type of remote control .....

f) Limited range required: Distance ..... m

g) Warning device provided .....

h) Any special control requirements against each drive to be indicated

k) Scheme of protection .....

m) Requirement of isolating switches and their positions

n) Type of monitor controller used, No. of steps

A-5.3 Motor Details

(Main Hoist, Aux Hoist, Long Travel and Cross Travel)

a) Approved manufacturers for motors .....

b) Class of insulation and protection .....

c) Duty classification .....

d) Frame size .....

e) Speed .....

f) kW rating .....

A-5.4 Main Hoist Limit Switches/Aux. Hoist Limit Switches

a) Shunt/Counterweight .....

b) Control voltage/power .....

A-5.5 Load Weighing System (Load Cell)

a) Compression type .....

b) Tension type .....

c) Display unit .....

A-5.5.1 *Resistance Details* M.H. A.H. C.T. L.T.

a) Type ....

b) Rating ....

c) Steps ....

A-5.6 Type of Traverse Current Collection System

A.5.7 Details of Bridge Lighting, Underbridge Lighting Provided, Warning Lights and/or Alarm System Provided

A-5.8 Cabin Facility Provided by

Fan/Air-conditioning/Cabin heating/others

A-6 ENVIRONMENTAL REQUIREMENTS

A.6.1 General State of Atmosphere or Climate

A.6.2 Average Ambient Temperature

Maximum temperature ..... °C

Minimum temperature ..... °C

Maximum humidity .....

A-7 SPECIAL SERVICE CONDITIONS

a) Use in saline atmospheres the degree of exposure should be stated.

b) The presence of any local heat sources such as furnaces or radiant space heating panels.

c) The need for special precautions against termites.

d) Any physical obstructions not apparent from the dimensions provided for clearances.

e) In the case of floor pendant controlled cranes, any differences in the operating floor level.

f) Any requirement concerning head room above servicing platforms.

g) Wind loading.

h) Any other abnormal atmosphere.

j) Any other conditions.

k) Are there other cranes on the same gantry or in the vicinity ? Yes / No

If yes whether special devices are required to prevent collision of the cranes or their loads or for separating the cranes by a minimum distance in order not to cover stress the gantry structure.

A-8 DETAILS OF LUBRICATION

a) Type (group/centralised) .....

b) Capacity .....

A-9 DETAILS OF WIND CLAMPS

a) Type (Mechanical/Motorised) .....

b) Type of interlocking system .....

A-10 STRUCTURAL DETAILS

A.10.1 Gantry : Existing/New, size .....

A-10.2 Rail : Size of rail .....

A-10.3 Wheel Loads

a) Minimum wheel load .....

b) Maximum wheel load .....

c) Spacing of wheels .....

A-10.4 Dimensions (*see* Fig. 2A and 2B)

Span S ..... m; +A2 ..... mm

Width of rail head B ..... mm

Side clearances X ..... mm Y ..... mm

Z ..... mm

Clearances from any obstruction from top of rail C ..... mm

Rail height from floor D ..... mm

Dimensions of knee bracking on truss

P1 ..... mm P2 ..... mm

T1 ..... mm T2 ..... mm

Hook travel for

Main hoist H1 ..... mm H2 ..... mm

Auxiliary hoist H3 ..... mm H4 ..... mm

Position of hook from centre line of rails for

Main hoist E ..... mm F ..... mm

Auxiliary hoist E1 ..... mm F1 ..... mm

Vertical clearance under side bridge ..... K-mm

Position/Height of

Cabin L ..... mm M ..... mm

Size of cabin N ..... mm Width ..... mm

Highest point of obstruction L1 ..... mm L2 ..... mm

Any other site restrictions

A-11 PAINTING

a) Prime coat .....

b) Two finishing coat .....

A-12 ANY SPECIAL STATUTORY OR TECHNICAL REQUIREMENT

a) Total weight of the crane (in MT) .....

b) Weight of the girder .....

c) Weight of the girder and platform .....

d) Weight of the end carriage with wheels .....

e) Weight of the trolley .....

f) Trolley span .....

g) Weight of the cabin .....

h) Type of festooned cable system .....

ANNEX B

(*Clause* 4.1.2)

DETERMINATION OF FATIGUE REFERENCE STRESS

B-1 GENERAL

A fatigue reference stress is used in the process of evaluating the fatigue strength. This annex outlines a method of determining the fatigue reference stress for component detail. Some guidance is given here for more usual cases on the determination of limit stresses not to be exceeded, in terms of the cycle of variation of loading to which the component detail under consideration is submitted and of the various factors which influence the resistance of parts to fatigue.

B-2 FATIGUE REFERENCE STRESS P_{fr}

$$P_{fr} = C_{fr} \times f_{ult}$$

where

f_{ult} = minimum ultimate tensile stress of the material, and

C_{fr} = fatigue reference stress factor.

B-3 DETERMINATION OF FATIGUE REFERENCE STRESS FACTOR 'C_{fr}'

For steel having minimum ultimate tensile stress not greater than 1 100 N/mm the factor C_{fr} can be determined from the following formulae in which N is the total number of cycles.

For $N \geq 10^6$; $C_{fr} = C_{lim} \times B_1$

For $10^3 < N < 10^6$ $C_{fr} = AC_{lim}$

where

$A = 1 + B_2$ for *bending stresses*

$A = 3$ for *torsion shear stress*

$$B_1 = \left(\log \frac{N}{3} - 1\right)$$

$$B_2 = \left(\log \frac{N}{6} - 1\right)$$

B-4 FATIGUE LIMIT FACTOR C_{lim}

The fatigue limit factor C_{lim} is the value of C_{fr} corresponding to the fatigue endurance limit:

$$C_{lim} = \frac{C_1}{C_2 \times C_3 \times K_f \times K_c}$$

where

C_1 = stress state factor,

C_2 = size factor,

C_3 = surface finish factor,

K_f = fatigue notch factor equal to K_{bf} for bending, and

K_c = factor for the miscellaneous effect.

B-5 DETERMINATION OF C_1, C_2, C_3, K_f AND K_c FACTOR

B-5.1 Stress Factor C_1

The value of C_1 is given in accordance with the nature of the stress cycle as follows:

$C_1 = 0.85$ for unidirectional bending

$$0 < f_{min} / f_{max} \leq 1$$

$C_1 = 0.50$ for reversing bending $-1 \leq f_{min} / f_{max} < 0$

$C_1 = 0.50$ for unidirectional torsion $0 < f_{min} / f_{max} \leq 1$

$C_1 = 0.30$ for reversing torsion $-1 \leq f_{min} / f_{max} < 0$

B-5.2 Size Factor C_2

The size factor is derived from Fig. 4.

B-5.3 Surface Finish Factor C_3

The surface finish factor is dependent on the ultimate tensile stress of the material and the machining process used in manufacturing. The value of C_3 is given in Fig. 5 in which R_t is the peak to valley height of surface roughness in micro mm.

B-5.4 Fatigue Notch Factor K_{bf}, K_{sf}

The presence of such details as shoulders, grooves, holes, key-ways, threads, etc, result in a modification of the simple stress distribution that would occur in members which have a constant cross section with gradual changes in contour. The resulting localization of high stresses is measured by the stress concentration factor defined as follows:

$$K_b = \frac{f_{b\,Max}}{f_{b\,Nom}} \text{ for bending stresses}$$

$$K_s = \frac{f_{s\,Max}}{f_{s\,Nom}} \text{ for torsional shear stress}$$

where

$f_{b\,Max}$ and $f_{s\,Max}$ = maximum stresses in a component detail, and

$f_{b\,Nom}$ and $f_{s\,Nom}$ = nominal stresses at the corresponding location (without considering the effect of notch).

The effect of a notch on the fatigue strength of a part varies considerably with material and notch geometry and is normally less than would be predicted by the use of the stress concentration factor. The general phenomenon is denoted as notch sensitivity. For the design purposes following relations apply :

$$K_{bf} = q\,(K_b - 1) + 1$$

$$K_{sf} = q\,(K_b - 1) + 1$$

where

q = notch sensitivity factor.

For the ductile materials the value of 'q' may be obtained from established reference works or from experimental data. Where no data exists, a value of $q = 1.0$ should be used in deriving K_{bf} and K_{sf}. For brittle material $q = 1.0$ shall be used in all cases.

Stress concentration factors K_b and K_s are to be obtained from established reference works. For the treatment of multiple stress concentrations in close proximity, reference should be made to established reference works.

B-5.5 Factor for Miscellaneous Effects K_e

Corrosion, electrolytic plating, metal spraying and residual stresses can have a very appreciable effect on the endurance limit of steels under certain conditions. Factor for miscellaneous effect K_e is to be obtained from established reference works.

ANNEX C

NOTES ON DESIGN AND SELECTION OF MOTORS

C-1 SELECTION OF MOTORS FOR HOIST MOTIONS

For hoisting motor the power required shall not be less than that computed from the following:

$$\text{kW} = \frac{MVC_v C_{dr}}{6.12\,E} \times \frac{1}{C_{amb}}$$

where

dc rating factor will be taken as 12 percent,

kW = one hour power rating for dc motors and power rating at (S – 40 percent) cyclic duration factor for a.c. motors,

M = mass of the rated load on the hook plus weight of the hook block and the wire ropes in tonnes,

V = specified hoisting speed in M/min,

E = combined efficiency of gears and sheaves

$= (0.93)^n \times (0.98)^m$ for sleeve bearings,

$= (0.95)^n \times (0.99)^m$ for anti-friction bearings,

$= (0.985)^n \times (0.99)^m$ for hardened profile ground and oil splashed lubricator

where

n = number of pairs of gears,

m = total number of rotating sheaves passed over by each part of the moving rope attached to the drum,

C_v = service factor for vertical motion depending on type of motors,

= 0.67 for ac motors

= 0.5 for dc motors

C_{df} = duty factor as defined in 6.4.3, and

C_{amb} = derating factor for ambient temparature as given in the Table 20A.

Table 20A Ambient Temperature for Derating Factor

Ambient Temperature	Derating Factor, C_{amb}
40°	1.00
45°	0.95
50°	0.88
55°	0.83
60°	0.75

For an ac hoist motor, the specified full load hoist speed must be obtained at not more than rated torque, therefore, the calculated full load kW must be multiplied by :

$$\frac{(100 \text{ - rated slip percent})}{(100 - \text{total ohms at full speed percent})}$$

Where sufficient information is not available values given in Table 20B for duty cycles, cyclic duration factor and starting class corresponding to mechanism class shall be used.

The values given are based on the following formula:

$$\text{Cyclic duration factor} = \frac{\text{Operating time} \times 100}{\text{Operating tme + idle time}}$$

The starting class (C) assumes numbers of complete starts (S), jogging operations (J) and electrical braking operations (B) as follows:

$$C = S + K_1 J + K_2 B$$

where

K_1 = 0.25 for slip ring motors

= 0.5 for squirrel cage motors

K_2 = 0.8 for slip ring motors

= 3.0 for squirrel cage motors

Table 20 B Recommended Cyclic Duration Factor and Starting Class

(*Clause* C.1)

Mechanism Class	Duty Cycle Number of Cyclic Class (C) Cycles/hour percent	Recommended Cyclic Duration Factor percent	Starting Class (C) Equivalent Starts/hour
M1	Up to 5 cycles 25	25	90
M2	Up to 5 cycles 25	25	90
M3	10 to 15 cycles 40	40	150
M4	16 to 20 cycles 40	40	150
M5	21 to 30 cycles 60	60	300
M6	31 to 40 cycles 60	60	300
M7	41 to 50 cycles 100	100	600
M8	51 to 60 cycles 100	100	600

C-2 MOTOR FOR CRANE TRAVEL OR TROLLEY TRAVERSE

C-2.1 General

It is assumed that the drive mechanism from the motor to the track wheels will use enclosed gearings mounted on anti-friction bearings. The actual efficiency of the drive will be adopted in making calculations. Where actual efficiency values are not available the efficiency of the drive shall be taken in the range of 0.85 to 0.9.

For the track wheel with anti-friction bearings the rolling friction at these bearings plus the friction between the track wheels with an average drive efficiency of 0.875 will give an overall friction factor of 8.0 kgf per tonne of the mass moved for calculation of the motor horse power or torque. In the case of wheels with the plain bearings an overall friction factor of 13.0 kgf per tonne of the mass moved may be used.

C-2.2 Selection of Motors for Crane Travel or Trolley Traverse

For bridge travel or trolley traverse the power of the motor required shall not be less than that computed from the following:

$$\text{kW} = \frac{MVSC_{df}}{6\,117T}\left(F + \frac{1\,100_s}{981N}\right) \text{ for indoor cranes}$$

$$kW = \frac{MVSC_{df}}{6\,117T}\left(F + \frac{1\,100a}{981N}\right) + \frac{R_w V}{6\,117T} \text{ for}$$

out door cranes

where

kW = one hour power rating for d.c. motors and power rating at 40 perent cyclic duration factor for a.c. motors;

M = mass of crane or trolley plus mass of max rated load in tonnes;

V = specified free running speed M/min;

N = mechanical efficiency of gearing. For spur and helical gears it can be taken as 0.95 per reduction;

T = factor introduced by the permissible motor torque during acceleration exceeding the motor-rated torque. As a general guidance value of T may be taken as 1.7 for motors having pull out torque of 275 percent full load torque. Lower values of T should be taken for corresponding lower values of pull out torque.

= 1.3 for d.c. motors pullout torque × 100

= 1.6 for a.c. motors 160 × full load torque

F = overall friction factor

= 8 kgf per tonne for wheels on anti-friction bearings

= 13 kgf per tonne for wheels on plain bearings

C_{df} = duty factor as defined in **6.4.3**;

Rwl = load due to service wind acting horizontally as defined in **6.3.1** which can be obtained by multiplying the horizontal exposed area by the service wind by taking drag co-efficient into consideration;

a = average linear acceleration of the crane or the trolley in cm/s² till the mechanism reaches 90 percent of free running speed. For the values of average linear acceleration refer as given in Table 21A; and

S = service factor aimed at providing adequate motor heat dissipation capacity as given in Table 21B.

Table 21A Acceleration Values

(*Clause* C-2.2)

Speed to be Reached M/min	Condition		
	Acceleration in cm/s² Low and Moderate Speed with Long Travel	Acceleration in cm/s² for Moderate and High Speed (Normal Application)	Acceleration in cm/s² for High Speed with High Acceleration
240	—	50	67
190	—	44	58
150	—	39	52
120	22	35	47
100	19	32	43
60	15	25	33
40	12	19	—
25	10	16	—
15	8	—	—
10	7	—	—

Table 21B Values of Service Factors

(*Clause* C-2.2)

Bridge Service Factor		Trolley Service Factor
0.95	1.00	1.06

NOTES

1 Duty cycle, recommended cyclic duration factors and recommended starting Class for the mechanism class can be taken from Table 20B.

2 At free running speed the acceleration becomes zero.

3 The gear reduction ratio actually used should be reasonably close to the ideal reduction ratio:

$$= \frac{\text{Motor rev/min at free running}}{\text{Track wheel rev/give specified running speed}}$$

4 In order to limit the acceleration to the specified value and also to take full advantage of the service factor the electrical control should be designed to suit the values of 'S' and 'T' actually adopted or values of 'S' and 'T' should be selected based on electrical controls to be provided.

5 Since the wheels must transmit all acceleration forces to the crane, to prevent wheel skidding due consideration should be given on percent driven wheels after acceleration rate has ben fixed. The wheel skidding should be checked at no-load conditions considering 20 percent adhesion betwen wheel and rail.

ANNEX D

INTERMITTENT RATINGS FOR RESISTORS

D-1 GENERAL

The basis of the rating shall be the ratio of the running time to a total time of 15 min and the resistors are rated to carry the rated full load motor current in any section or sections except where current is restricted to lower value by the amount of resistance in the circuit in which case the resistor shall be rated to carry the current passed with the motor at stand still.

D-2 DEFINITION OF DIFFERENT RATINGS

D-2.1 Two Minute Rating

A resistor having a two minute rating shall be capable of being left in the circuit for a period not exceeding 30 s on the first section and for a further period of 90 s divided between the remaining sections of the resistor, followed by a period of rest of 13 min, this cycle being repeated until a stable temperature is reached.

D-2.2 Five Minute Rating

A resistor having a five minute rating shall be capable of being left in circuit for a period not exceeding 2 min on the first section and for a further period of 3 min equally divided between the remaining sections of the resistor, followed by a period of rest of 10 min, this cycle being repeated until a stable temperature is reached.

D-2.3 Ten Minute Rating

A resistor having a ten minute rating shall be capable of being left in circuit for a period not exceeding 4 min on the first section and for a further period of 6 min equally divided between the remaining sections of the resistor, followed by a period of rest of 5 min, this cycle being repeated until a stable temperature is reached.

ANNEX E

(*Clause* 18.2)

CRANE-RECOMMENDED/PREFERRED PARAMETERS

E-1 GENERAL

To aid economic manufacture it is recommended that the crane parameters given in F-2 to F-4 be selected from a progression based upon the preferred number series.

E-2 PREFERRED LIFTING CAPACITIES

Preferred series R10 shall be used for capacities up to and including 125 tonnes and R20 for capacities above 125 tonnes. The preferred lifting capacities (in tonnes) are as follows:

1.0	3.2	10	32	100	225	400
1.25	4.0	12.5	40	125	250	450
1.6	5.0	16	50	140	280	500
2.0	6.3	20	63	160	320	560
2.5	8.0	25	80	200	360	etc.

E-3 PREFERRED LIFTING HEIGHT

Preferred series R5 shall be used for lifting heights up to and including 16m and R10 for heights above 16m. The preferred lifting heights (in metres) are as follows:

2.5	10	25	50
4.0	16	32	63
6.3	20	40	etc.

E-4 PREFERRED SPEED OF OPERATION (FULL SPEEDS)

Preferred series R5 and R10 shall be used for full speed of operation respectively. The preferred speeds of operation (in metres per minute) are as follows:

0.63	1.6	4.0	10	25	63	160
0.8	2.0	5.0	12.5	32	80	200
1.0	2.5	6.3	16	40	100	—
1.25	3.2	8.0	20	50	125	—

ANNEX F
(*Clause* 2.1)

LIST OF INDIAN STANDARDS

F-1 MATERIALS

F-1.1 Steels and Castings and Tubes

IS No.	*Title*
210 : 1993	Specification for grey iron castings (*fourth revision*)
1030 : 1989	Specification for carbon steel castings for general engineering purposes (*fourth revision*)
1239	Mild steel tubes, tubular and other wrought steel fittings:
(Part 1) : 1990	Mild steel tubes (*fifth revision*)
(Part 2) : 1992	Mild steel tubular and other wrought steel pipe fittings (*fourth revision*)
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
1570 : 1961	Schedule for wrought steel for general engineering purposes
2062 : 1992	Specification for steel for general structural purposes (*fourth revision*)

F-1.2 Threaded Fasteners

1364	Specification for hexagon head bolts, screws and nuts of product grades A and B:
(Part 1) : 1992	Hexagon head bolts (size range M1.6 to M64) (*third revision*)
(Part 2) : 1992	Hexagon head screws (size range M1.6 to M64) (*third revision*)
(Part 3) : 1992	Hexagon head nuts (size range M1.6 to M64) (*third revision*)
(Part 4) : 1992	Hexagon thin nuts (chamfered) (size range M1.6 to M64) (*third revision*)
(Part 5) : 1992	Hexagon thin nuts (unchamfered) (size range M1.6 to M10) (*third revision*)
1367	Tecchnical supply conditions for threaded fasteners:
(Part 6) : 1994	Mechanical properties and test methods for nuts with specified proof loads (*third revision*)
(Part 7) : 1980	Mechanical properties and test methods for nuts without specfied proof loads (*second revision*)
(Part 9/Sec 2) : 1979	Surface discontinuities, Section 2 Bolts, screws and studs for special application (*second revision*)
(Part 10) : 1979	Surface discontinuities on nuts (*second revision*)
(Part 12) : 1981	Phosphate coating on threaded fasteners (*second revision*)
(Part 13) : 1983	Hot-dip galvanized coatings on threaded fasteners (*second revision*)
(Part 14) : 1984	Stainless steel threaded fasteners (*second revision*)
(Part 16) : 1979	Designation system and symbols (*first revision*)
(Part 18) : 1979	Marking and mode of delivery (*second revision*)
3640 : 1982	Hexagon fit bolts (*first revision*)
3757 : 1985	High strength structural bolts (*second revision*)
6639 : 1972	Hexagonal bolts for steel structures

F-1.3 Wire Rope

1856 : 1977	Specification for steel wire ropes for haulage purposes (*second revision*)
2266 . 1989	Specification for steel wire ropes for general engineering purpose (*third revision*)

IS No.	Title
2365 : 1977	Specification for steel wire ropes for lifts, elevators and hoists (*first revision*)
2762 : 1982	Specification for wire rope slings and sling legs (*first revision*)
3973 : 1984	Code of practice for selection, installation and maintenance of wire ropes (*first revision*)
6594 : 1977	Technical supply conditions for steel wire ropes and strands (*first revision*)

F-2 MECHANICAL AND FABRICATION DETAILS

F-2.1 Key and Key-ways

2048 : 1983	Specification of parallel keys and key-ways (*second revision*)
2291 : 1981	Specification for tangential keys and key-ways (*second revision*)
2292 : 1974	Specification for taper keys and key-ways (*first revision*)
2294 : 1986	Specification for woodruff keys and key-ways (*second revision*)
6166 : 1971	Specification for thin taper key and key-ways
6167 : 1971	Specification for parallel keys and key-ways

F-2.2 Welding

816 : 1969	Code of practice for use of metal arc welding for general construction in mild steel (*first revision*)
818 : 1968	Code of practice for safety and health requirements in electric and gas welding and cutting operation (*first revision*)
822 : 1970	Code of procedure for inspection of welds
1024 : 1979	Code of practice for use of welding in bridges and structures subject to dynamic loading (*first revision*)
1323 : 1982	Code of practice for oxy-acetylene welding for structural work in mild steel (*second revision*)
9595 : 1980	Recommendations for metal arc welding of carbon and carbon manganese steels

F-2.3 Gears

2467 : 1963	Notation for toothed gearing
2535 : 1978	Basic rack and modules of cylindrical gears for general engineering and heavy engineering (*second revision*)
3734 : 1983	Dimensions for worm gearing (*first revision*)
4460 : 1967	Method for rating of machine cut spur and helical gears
5037 : 1969	Basic rack and modules of straight bevel gears for general engineering and heavy engineering
6535 : 1979	Data for procurement of straight bevel gears (*first revision*)
7403 : 1974	Code of practice for selection of standard worm and helical gear boxes
7504 : 1974	Methods of inspection of spur and helical gear
10911 : 1984	Method of inspection for straight bevel gears

F-3 ELECTRICAL DETAILS

F-3.1 Motors

325 : 1978	Specification for three-phase induction motors (*fourth revision*)
900 : 1992	Code of practice for installation and maintenance of induction motors (*revised*)
1231 : 1974	Dimensions of three-phase foot mounted induction motors (*third revision*)
2223 : 1983	Dimensions of flange mounted ac-induction motors (*second revision*)

IS No.	*Title*
2253 : 1974	Designation for types of construction and mounting arrangement of rotating electrical machines (*first revision*)
4691 : 1985	Degrees of protection provided by enclosure for rotating electrical machinery (*first revision*)
4722 : 1968	Specification for rotating electrical machines
4728 : 1975	Terminal marking and direction of rotation for rotating electrical machinery (*first revision*)
12065 : 1987	Permissible limits of noise level for rotating electrical machines
F-3.2 Cables and Conductors	
9968	Specification for elastomers insulated cables :
(Part 1) : 1988	For working voltages up to and including 1 100 V (*first revision*)
(Part 2) : 1981	For working voltages from 3.3 k V up to and including 11 k V
694 : 1977	Specification for PVC insulated cables for working voltages up to and including 1 100 V (*second revision*)
1554	Specification for PVC insulated (heavy duty) electric cables:
(Part 1) : 1988	For working voltages up to and including 1 100 V (*third revision*)
(Part 2) : 1981	For working voltages from 3.3 kV up to and including 11 kV (*second revision*)
8130 : 1984	Specification for conductors for insulated electric cables and flexible cords (*first revision*)
F-3.3 Switch Gear	
2516 : (Parts 1 & 2/ Sec 1) : 1985	Specification for circuit breakers : Parts 1 & 2 Requirements and tests, Section 1 Voltages not exceeding 1 000 V ac or 1 200 dc (*second revision*)
3427 : 1969	Specification for metal-enclosed switchgear and control gear for voltages above 1 000 V but not exceeding 11 000 V
8544	Specification for motor starters for voltages not exceeding 1 000 V:
(Part 1) : 1977	Direct-on-line ac starters
(Part 2) : 1977	Star-delta starters
(Part 3/Sec 2) : 1977	Rheostatic motor starters, Section 2 Additional requirements for ac rheostatic motor controllers
(Part 4) : 1979	Reduced voltages AC-starters, two-step auto transformer starters
10118	Code of practice for selection, installation and maintenance of switchgear and controlgear:
(Part 1) : 1982	General
(Part 2) : 1982	Selection
(Part 3) : 1982	Installation
(Part 4) : 1982	Maintenance
13947 (Part 1) : 1993	Low-voltage swicthgear and controlgear : Part 1 General rules
13118 : 1991	High voltage alternating current circuit breakers
F-3.4 Earthing	
3043 : 1987	Code of practice for earthing
F-3.5 Conduits	
9537	Conduits and electrical installations:
(Part 1) : 1980	General requirements
(Part 2) : 1980	Rigid steel conduits
(Part 3) : 1981	Rigid plain conduits of insulating materials
(Part 4) : 1983	Pliable self-recovering conduitsof insulating materials

IS No.	*Title*
F-3.6 Cranes	
807 : 1976	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and holes (*first revision*)
4137 : 1985	Code of practice for heavy duty electric overhead travelling cranes including special service machines for use in steel work (*first revision*)
4728 : 1975	Terminal marking and direction of rotation for rotating electrical machinery (*first revision*)
13743 (Part 1) : 1992	Cranes — Vocabulary : Part 1 General
13834	Cranes :
(Part 1) : 1994	General
(Part 5) : 1993	Overhead travelling and portal bridge cranes
13870 (Part 1) : 1993	Cranes and lifting appliances — Selection of wire ropes : Part 1 General

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