Industrial Motors
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Marathon Industrial KS Slip-Ring Motors

May 2025
India

marathon™ WEG Group

Driving efficiency and sustainability

WEG

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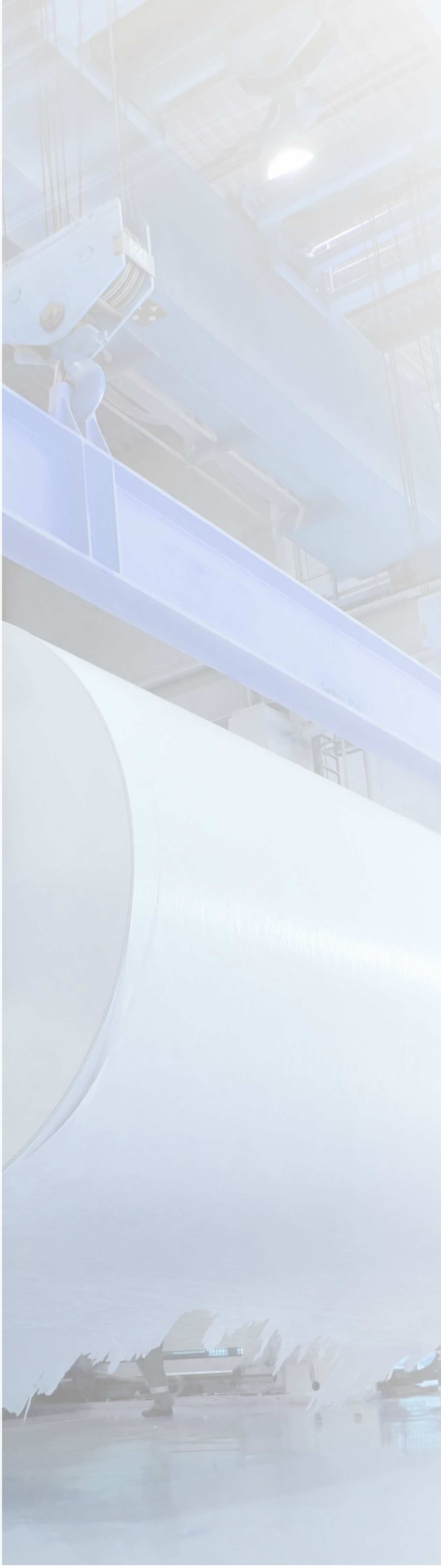
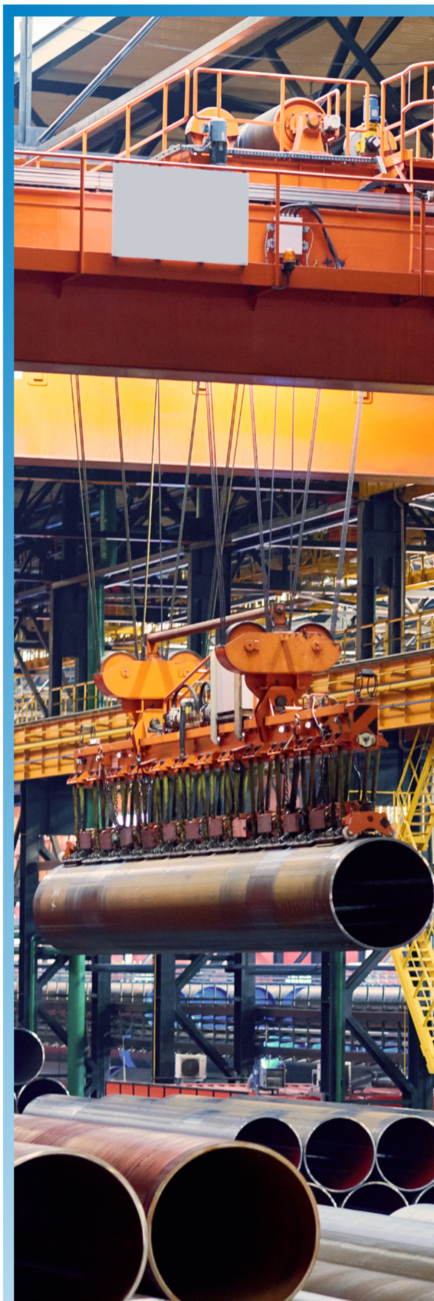


MARATHON® KS SLIP-RING MOTORS

Marathon Krane Range Motors have been specifically designed for crane applications and the mechanical features are such that they are particularly suitable for this duty.



APPLICATIONS

Marathon Low Voltage Heavy Duty Wound Rotor Krane Range Motors have been designed and rated for driving, hoisitng, hauling and other intermittently operated machinery in the metal industries.

FEATURES

- Metric dimensions as per IEC®* : 60072-1/ IS1231
- Totally enclosed weather protected IP55-IC411
- High ratio of pullout torque/rotor inertia
- Ratings up to approximately 450kW
- Larger outputs available for certain specific requirements
- Supply voltages up to 690 Volts
- Ambient temperature 45°C (upto KS 315 frame) and
  Ambient temperature 40°C (KS 355 Frame - KS 500 Frame)
- Insulation class F/F (stator/ rotor) with temperature rise limited to class B/B

STANDARDS AND SPECIFICATIONS

- Standard Krane Range Motors comply with the requirements of IPSS: 1-03-003-08
- **Degree of Protection by enclosure:** IP55 and conforms to the requirements of IEC: 60034-5 & IS/IEC: 60034-5
- **Cooling Form:** Totally enclosed fan-ventilated IC411 to IEC: 60034-6 and IS: 6362
- **Mounting Arrangements:** There are in accordance with IEC : 60034 -7. The standard motors are foot mounted as per IS : 1231. Foot cum flange and horizontal flange mounting arrangements are available if required.
- **Ratings and Performance:** Krane Range motors comply with the requirement of IEC: 60034 -1, IS: 15999-1 & 1-03-003-08

*IEC is a trademark or trade name of International Electrotechnical Commission not owned by or under the control of Marathon Electric.

SUPPLY AND OPERATING CONDTIONS

- **Rated Voltage:** voltage between line terminals of the motor are rated output.
- **Preferred Voltages:** preferred voltages for the Krane 50Hz Motors are 220, 380, 415, and 440 volts, although most outputs are available with other supply voltages up tp 690 volts.
- **Supply Neutral Condition:** the motors are designed for continuous operation with the supply neutral at or near earth potential but they are also capable of operation on an unearthed system with one line at earth potential continuously.
- **Voltage variation during operation:** standard motors are capable of supplying rated output, at a rated speed, at a voltage within 90% to 110% of its rated voltage. However, if motors are required to operate continuously at these limits, this can result in an excess temperature rise of 10K. Such operation at extreme voltage is recommended for short duration.
- **Unbalance:** standard motors are capable of opearting under conditions of supply system unbalance provide the negative and zero phase voltage do not differ by more than 5% of the fundamental wave of the same phase voltage.
- **Combined effect of unbalance and non-sinusoidal supply:** standard motors are capable of operating with a simultaneous combination of the "unbalance" and "waveform" conditions detailed above. Supply through thyristor control units sometimes require derating of motors. Please refer to Marathon Electric office for details of proposed supply.

ELECTRICAL DESIGN

FREQUENCY

The standard frequency is 50Hz, although motors can be supplied for operation at specified alternative frequency of 60 Hz. Please refer to Marathon Electric Sales Team for further information.

Standardard motors are capable of operatin continuously on full load at any frequency between 95% and 105% of the nominal frequency.

AMBIENT/ALTITUDE

- **Normal limit of coolant temperature:** Standard motors are designed for operation with a coolant air temperature (i.e. a motor ambient temperature) not exceeding 45°C (up-to KS 315 frame) and ambient temperature 40°C (KS 355 frame - KS 500 frame). Temperature rise is measured by the increase in winding resistance
- method and above specific ambient temperature.

- **Variation in output with coolant temperature:** When motor is operated with the cooling air at a temperature different from the above specified ambient temperature, the allowable output can be adjusted from the adjacent table.

Table 1A - For motor up to KS 315

Coolant Air temperature °C	Approximate permissible output %
up to 30	106
Over 30 up to 35	103
Over 35 up to 45	100
Over 45 up to 50	95
Over 50 up to 55	90
Over 55 up to 60	85

Table 1B - For motor in frame KS 355 - KS 500L

Coolant Air temperature °C	Approximate permissible output %
up to 30	106
Over 30 up to 35	103
Over 35 up to 40	100
Over 40 up to 45	95
Over 45 up to 50	90
Over 50 up to 55	85
Over 55 up to 60	80
above 60	Refer to Marathon Electric office.

- **Variation in output with altitude:** Standard motors are designed for operation at any altitude from sea level up to 1000 metres. See the adjustment table below for details of allowable temperature. When the coolant temperature at site is unspecified and the specified altitude is greater than 1000 metres and up tp 4000 metres. It is assumed that the reduced cooling resulting from altitude is compensated for by a reduction in coolant temperature and that no adjustments to the normal permissible temperature rises and outputs are necessary.

Table 2

Altitude above Sea level Metres	Approximate permissible output %
1000	100
1500	95
2000	91
2500	87
3000	83
3500	79
4000	74
above 4000	Refer to Marathon Electric office.

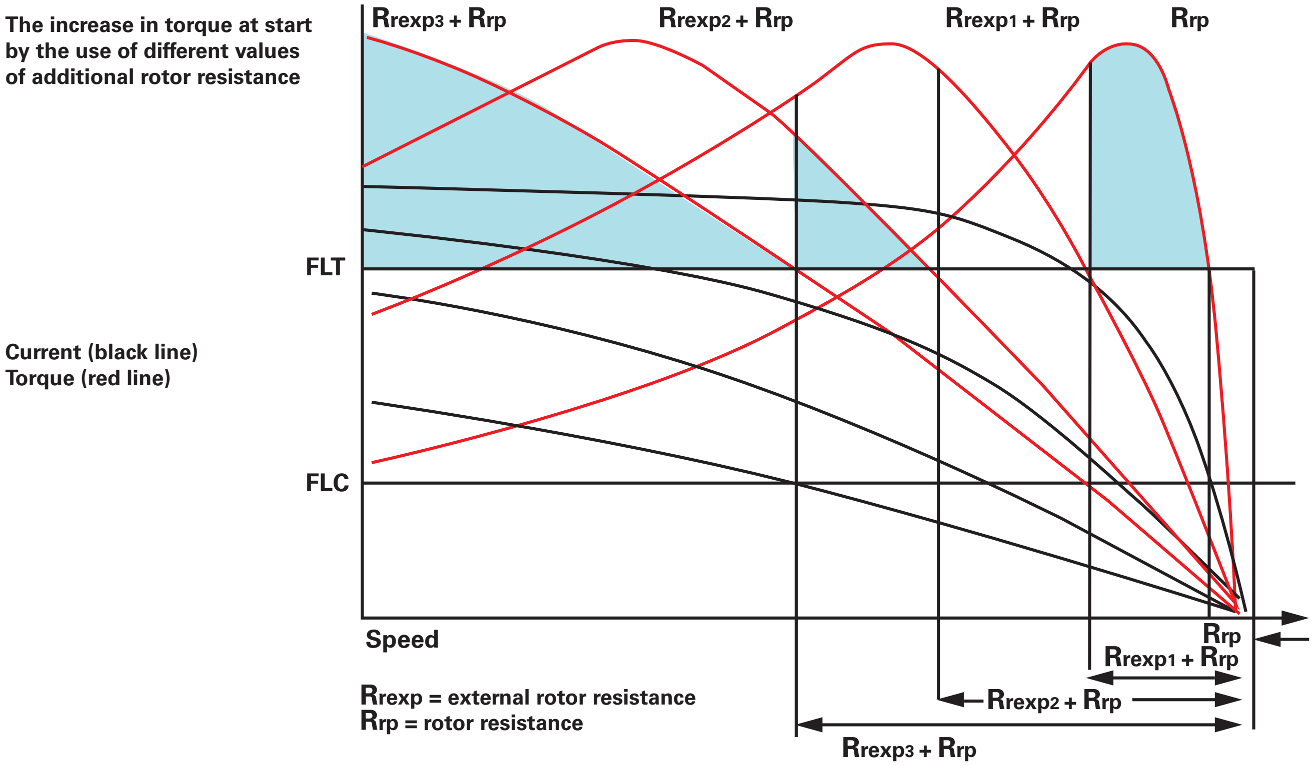
- **Combined Variation of Coolant Temperature and Altitude:** If both the temperature of the coolant and the site altitude differ from the standard, the approximate permissible output is obtained by multiplying the % factors for each variable as given below:

E.g motor rating - 160kW with class F insulation
Coolant temperature 45°C Factor 95% (Table1B) +
Altitude 2000m Factor 91% (Table2) + Overall factor 86.4%
Therefore frames should be selected on the basis of an output equal to:

$$160 \times \frac{100}{86.4} = 185.2\text{kW}$$

METHODS OF STARTING

Wound rotor motor are normally started by means of a short time rated variable resistance in the rotor circuit. The resistance may be graduated in steps consistent with the current/ torque requirements, or infinitely variable if a liquid-type resistance is used. Such a resistance may be used to increase the starting torque up to the value of the maximum torque with a stator current approximately 2.5 times normal full load current for motors having a pull out torque approximately 2.5 times full load torque. Starting schemes using vacuum contactors are also suitable for low voltage Krane Range Motors.



Calculation of external starting resistance required for specific starting torque

If:
Rrexp = external rotor resistance per phase required to give a torque T_a at standstill (ohm)
Vroc = rotor open-circuit voltage (volt)
Irf = rotor current at rated output (amp)
Tf = torque at rates outputs
Ta = torque required at standstill
(Same units for both)
Rrp = rotor winding resistance per phase
n_s = synchronous speed (r/min)
n_f = speed at rated output (r/min)

k is variable with line drop, motor leakage reactance and motor resistance. A value of 0,8 may be taken for general use, whilst noting that extreme values in the regions of 0,6 and 1,0. Low values result from large line voltage drops and high machine reactances and vice versa

$$R_{rexp} = k \left[\frac{V_{roc}}{\sqrt{3}\, I_{rf}} \times \frac{Tf}{T_a} - R_{rp} \right]$$

R_{rp} is usually small compared to R_{rexp} and may be neglected but if an allowance is considered necessary it can be derived with sufficient accuracy from -

$$R_{rp} = \frac{V_{roc}}{\sqrt{3}\, I_{rf}} \times \frac{n_s - n_f}{n_s}$$

STARTING CLASSES

The starting class for a motor states the maximum permissible number of starts per hour, when driving a load not exceeding the specified inertia.

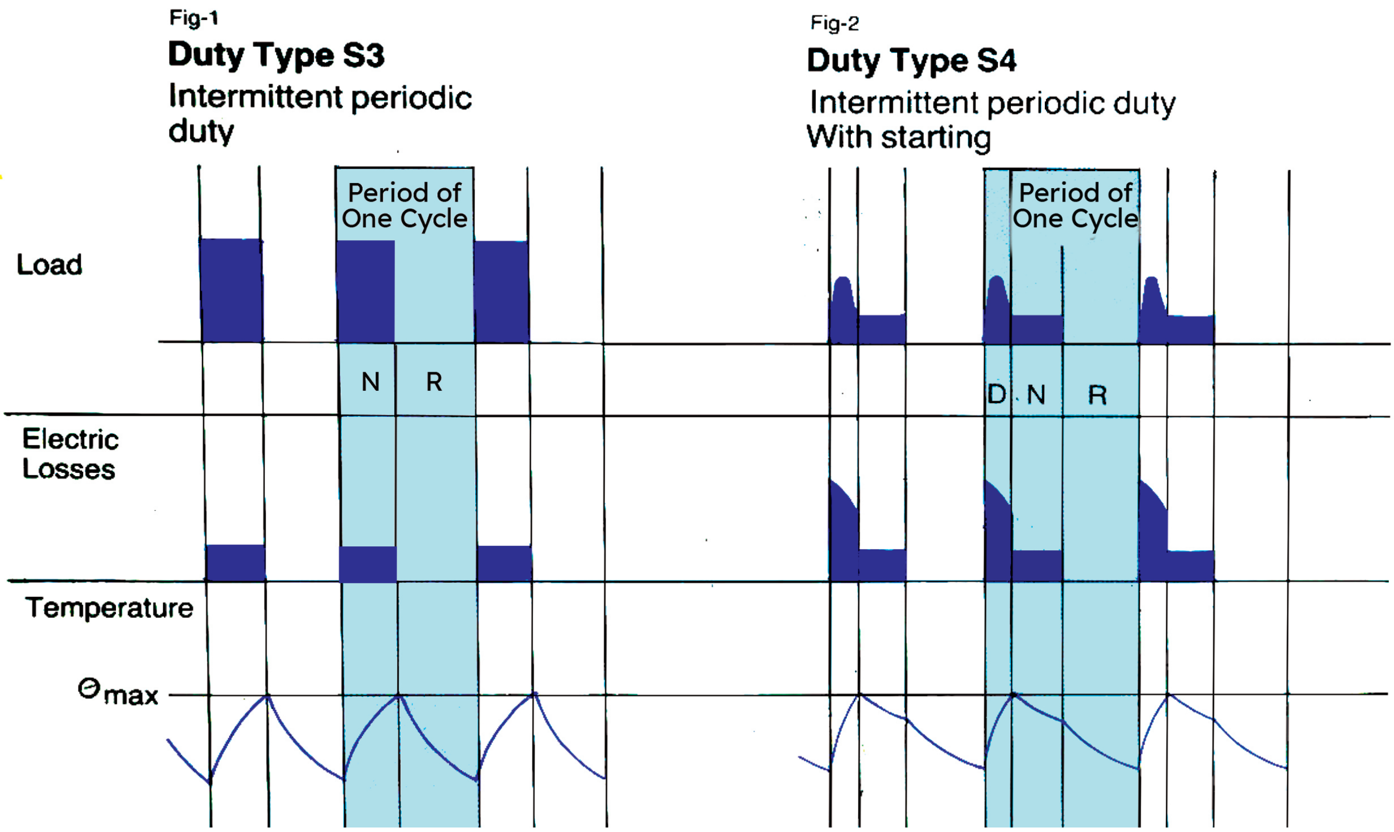
The standard Starting Classes are 6, 150, 300 and 600 starts per hour, taking into account complete starting, jogging or inching, and electric (plug) braking operations on the following bases:

- One jog (i.e. an incomplete start during which the motor does not reach more than 25% rated speed) is the thermal equivalent of 25% of a complete starting operation
- One plug braking operation down to a standstill is thermally equivalent to 80% of a complete start
- One complete plug reversal is thermally approximately 180% of a complete starting operation

CYCLIC DURATION FACTOR

The Cyclic Duration factor is defined as: **CDF** $\dfrac{\textbf{Period energised}}{\textbf{Duration of complete duty cycle}}$

DUTY TYPES



D = Starting
N = Operation under rated condition
R = At rest and de-energised
Ømax = Maximum temperature attained during the duty cycle

Cyclic Duration Factor = $\dfrac{D + N}{D + N + R}$

N = Operation under rated condition
R = At rest and de-energised
Ømax = Maximum temperature attained during the cycle

Cyclic Duration Factor = $\dfrac{N}{N + R}$

Krane Range Motors are rated on the periodic Duty System, which is based on a series of cycles identical in duration, length of time spent running, and at rest. The machine is never energised or de-energised long enough for it to reach thermal equilibrium with the ambient temperature during either the heating or cooling stage. The rating of the motors is such that the temperature rise at starting or during running does not exceed the maximum permitted motor temperature rise.

■ S3 Intermittent Periodic Duty

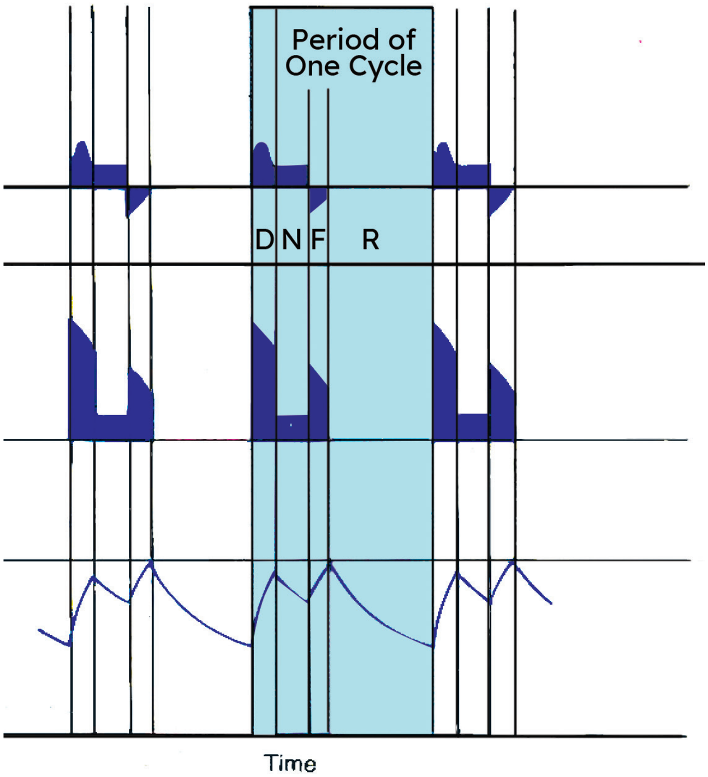
Based on a duty cycled of 10 minutes, i.e. 6 starts/hour, Figure 1 represents the condition in which heating during starting should not significantly affect the temperature rise, e.g. cycles of long duration. The higher outputs obtainable with the shorter cyclic duration factors result in relatively low pull-out torque.

Consequently 15% CDF, S3 rated motors are sutible for driving infrequently-operated machines, such as an ore unloader, apron hoist where the energised period is short (i.e. 1½ minutes).

Fig-3

Duty Type S5

Intermittent periodic duty
With starting & electric braking



D = Starting
N = Operation under rated condition
R = At rest and de-energised
Ømax = Maximum temperature attained during the duty cycle

$$\text{Cyclic Duration Factor} = \frac{D + N + F}{D + N + F + R}$$

The 60% CDF, S3 rated motor is suitable for driving longer working cycle, infrequently operated machines, such as an ore bridge or container crane with long travel drives.

The 100% CDF S3 rating specifies the permissible continuous rating outputs for situations where a Krange Range Motor may be used as a replacement for some continuously maximum ratings on the plant.

■ S4 Intermittent Periodic Duty with Starting

Classes 150, 300 or 600 (Fig.2). The duty cycle is short and heating is mainly due to the relatively high proportion of the cycle time used in starting and accelerating the load.

■ S5 Intermittent Periodic Duty with Starting and Electric braking See Fig. 3.

These duty types cater for the majority of crane motor applications. See Table 4 for typical combinations. Useful guidance for rating categories may be obtained from 'Rules for Design of Hoisting Appliances' Part II, Appendix A-2, 13 published by the European Materials Handlind Federation (Federation Europeenne de la Manutention), Paris, France and "General Code of Practice for Design of EOT Cranes" as per IPSS-2-12-004-94.

Table 4: Example of typical starting duties

Duty Type	Starting duties							Starting Class i.e. number of starts or thermal equivalent per hour
	Starts per hour		Jogs per hour		Brakings to standstill per hour		Complete plug reversals per hour	
S3	6	+	0	+	0	+	0	6
S3	4	+	8	+	0	+	0	
S4	150	+	0	+	0	+	0	
S4	100	+	200	+	0	+	0	
S5	80	+	0	+	80	+	0	150
S5	65	+	130	+	65	+	0	
S5	30	+	16	+	30	+	30	
S4	300	+	0	+	0	+	0	
S4	200	+	400	+	0	+	0	
S5	160	+	0	+	160	+	0	300
S5	130	+	260	+	130	+	0	
S5	60	+	320	+	60	+	60	
S4	600	+	0	+	0	+	0	
S4	400	+	800	+	0	+	0	
S5	320	+	0	+	320	+	0	600
S5	260	+	520	+	260	+	0	
S5	120	+	640	+	120	+	120	

PERMISSIBLE INERTIA OF DRIVEN PARTS

The listed CDF, rated output, and total inertia in KS data are interlinked to one another. Altering one of these three values will affect the other two. As the driven inertia has an increasing effect on motor heating with increasing number of starts per hour (i.e. 300 and 600), therefore, the inertia values initially given should be observed. When the running load is significantly less than quoted figure, the permissible load inertia may be increased for the lower number of starts per hour, using the following rules.

Rule 1

If the equivalent number of starts is lower then 150 or between two listed categories, then the total permissible inertia (i.e motor + load) for a given output can be varied in inverse proportion to the number of starts. Conversely, if the total inertia is within the specified limts, then for an equivalent number of starts other than standard, the listed output may be increased or decreased by proportioning between the two outputs for the number of starts nearest the required number.

In the case of long travel drives of the crane, it will sometimes be found that the motors chosen on the basis of maximum torque will appear to be inadequate on the basis of specified load inertia. See 'How to select a frame size' Example 2.

Rule 2

For Starting Class 150 duty, the permitted total inertia may be multiplied by 1.3 or 2.6 if the required running power (KW) does not exceed the rated output of the frame size in the Starting Class 300 or 600 tables respectively, for the required (or higher) Cyclic Duratin Factor. Similarly for Starting Class 300 the total inertia can be doubled if the rated output in the Starting Class 600 covers the requirements. If the inertia of the driven parts is still outside the value thus obtained, then please refer to Marathon Electric office.

OVERSPEED

All motors are capable of withstanding minimum of 2.5 times the rated speed or 2000 r.p.m., whichever is less.

PULL OUT TORQUE

The pull-out torques at rated voltage will be as specified in tables of KS data. However, as the available motor torque varies as the square of the supply voltage, an allowance may have to be made for voltage drop in long cable runs, live rails and collectors, etc. Since the current will be much higher than rated current, when working at pull-out torque, these voltage drops may be significant.

It must be remembered that the ratio of pull-out to rated torque is high for Starting Class 300 and 600. The higher pull-out torques with the Starting Class 300 and 600 rated motors ensure ample torque for rapid acceleration, despite the fall-off in effective torque due to stepped rotor resistance control. However gear manufacturers should be advised of these peak torques when inviting them to tender for drive transmission equipment.

MECHANICAL DESIGN

RATING PLATE

In line with IPSS recommendations the rating plates show output values at S3-40% CDF.

S3 & S2	6 Starts 60 Minutes	40% CDF	} These are equivalent
S4/S5 & S3	150 Starts 6 Starts	60% CDF 100% CDF	} These are equivalent

STATOR

Stator frames are elegant looking ribbed type, rugged in construction with integral feet arrangement. Up to KS450L frames are made of high quality grey cast iron conforming to IS210. Beyond KS450L, i.e. for frame sizes KS500/KS560, fabricated steel barrel construction frames with deep external welded fins are used. Lifting lugs of adequate strength are provided. For mill duty and other heavy duty applications M.S. fabricated frames are also available in frames KS450L and below.

Low loss high permeability electrical grade steel sheets are used for stator core. The core is assembled under pressure and secured by thick end-plates at both ends. The core winding is further keyed with the main frame.

For larger frame sizes depending on duty and specific requirement varnished glass taped/glass braided rectangular copper strip conductors may also be provided. The wound stators are multiple dipped in class F thermosetting varnish followed by baking which provides protection against moisture and other contaminants.

Higher grade of insulation (Class H) may be provided against speciific requirement. Thermistor/RTD may be embedded in stator winding if required.

ROTOR

The shaft is made from carbon steel (C45 of IS1570) / (EN8 to BS970) of large cross section to provide adequate strength pertraining to crane application. Shaft materials are duly checked for UTS/elongation. Complete shaft is ground finished and quality is assured through stringent stage inspection using ultrasonic flaw detector and magnetic particle crack detector. If desired higher grade shafting material (e.g. EN24 or above) may also be provided.

Like stators, the rotor is built up of similar laminations and keyed to shaft. The laminations are held in place by thick steel end plates provided at both ends secured by keyrings.

The dimensions of a complete rotor unit is designed so as to provide minimum rotor inertia.

Rotor windings are class F insulated as standard. Round copper wire conductors covered with modified polyester enamel are used for KS112M to KS250M framesize. For KS280S and above varnished glass taped rectangular copper strip conductors are used. Multiple dipping and baking in class F thermosetting varnish completes the insulation system. The integral system of wire and slot insulation and overall varnish impregnation withstands high moisture and chemical contamination and provide the best tracking protection together with a winding rigidity capable of withstanding the vibration limits imposed by the drives.

SHAFT ORIENTATION

Standard motors are provided with bare cylindrical shaft extension at driving end. Double Cylindrical/ Double tapered shaft extension as per IPSS requirement is also available.

STUB SHAFT can aslo provided for tachometer generator mounting, when specified.

BALANCING

All rotors are dynamically balanced in two planes using a precision balancing machine having high sensitivity. The sensitivity of the machine is maintained by regular checks using test mandrels. Complete rotor assembly with fan is dynamically balanced initially without external fan and then finally balanced and checked by adding weights on fan.

Vibration levels for complete motors are maintained within the specified limits of normal class of vibration as per IS12075.

END SHIELD

The end shields are manufactured from high quality grey cast iron of adequate thickness. Ribbed reinforcement are provided in higher sizes for increased strength and rigidity. The end shields are highly resistant to mechanical shock and are spigotted and bolted to ensure a positive alignment.

FAN AND AIRSHIELD

Bi-directional cast aluminum alloy fans or M.S. fabricated fans and M.S. fabricated/liberally reinforced split cast iron airshield are used for all motors. Fans and airshields are so designed as to achieve the most efficient ventilation.

BEARING AND LUBRICATION

Metric size medium series ball and roller bearing are provided. For frame size up to and including KS 315L ball/ball bearing arrangement is provided while large frame size from KS355S to KS500L have cylindrical roller bearing at driving end and deep groove ball bearing at non driving end. For KS560L frame size cylindrical roller bearings are provided at both ends with an additional locating ball bearing at the non driving end.

The bearings are lubricated with premium grade Lithium based grease SHELL®* GADUS®* S2 V100 which contains oxidation and corrosion inhibitors. Regreasing points are incorporated as standard. Grease relief valves can be fitted if specified at the time of ordering. Table 5 shows bearing sizes and recommended regreasing intervals for motors oprating at 45°C (maximum) ambient temperature.

Table 5: Bearing sizes and recommended re-greasing interval (Operating at an ambient temperature 40°C)

Frame Size	D.E.		N.D.E.	
	Bearing Sizes	Interval (Hours)	Bearing Sizes	Interval (Hours)
KS112M	6306ZZ	-	6306ZZ	-
KS132M	6308ZZ	-	6308ZZ	-
KS160M/L	6309ZZ	-	6309ZZ	-
KS180L	6310ZZ	-	6310ZZ	-
KS200L	6312	8000	6312	8000
KS225S/M	6314	8000	6314	8000
KS250S/M	6315	8000	6315	8000
KS280S/M	6317	8000	6317	8000
KS315S/M/L	6319	5000	6319	8000
KS355S/M/L	NU321	8000	6321	8000
KS400L	NU324	4000	6324	4000
KS450L	NU324	4000	6324	4000
KS500L	NU326	3,400	6326	3400

Based on 1000 RPM (6P).
For 750 and 600 RPM motors the greasing interval will be more.

SLIP-RINGS AND BRUSHGEAR

Internal slip-rings are fitted on all motors. Three copper-nickel slip-rings are part of fabricated slip-rings with fibre glass or mica insulation. The slip-rings assembly is then pressed and keyed onto the shaft. For KS112M-KS315M slip-ring is positioned at N.D.E. side, whereas for KS355 and above slip-ring is positioned at the D.E. side. The internal brush gear is carried on insulated spindles attached to N.D.E. inner bearing cap and can be easily serviced via inspection windows at each side of the motor. Independently spring loaded brushes are mounted in box type holders with either two or four brushes per slip-ring depending on current rating. The brush pressure can be adjusted by adjustable coil springs.

TERMINAL BOX

Terminal boxes are designed with ample dimensions to facilitate ease of cabling and connection. Terminal arrangement conforms to relevant IS Specification/IPSS requirement. For frame sizes KS355 to KS450, the design provides an arrangement to allow locationing of terminal box in any of three positions-TOP, RHS & LHS. For frame sizes KS500 and above five alternative positions are provided. The remaining two or four openings are used as inspection covers for maintenance of carbon brushes/slip-rings. Optional arrangement of hinged inspection cover available.

For frame size KS355 and above terminal box as well as the brush-gear arrangement is off-set axially towards the driving end with the following advantages:

i) Improved cooling.

ii) Easier access and ample increased space for the maintenance of slip-ring/carbon brushes.

iii) Facilities to view collector gear functioning while the motor is in operation.

As a standard feature, conduit plates are supplied with the Terminal Box. Against specific requirement suitable trifurcating/ cable sealing and dividing box with glands can be provided.

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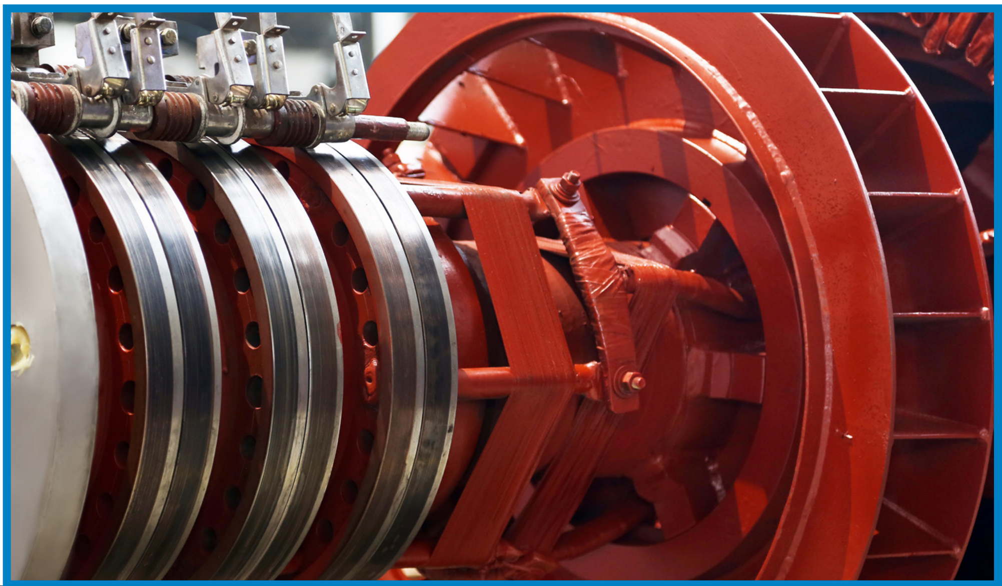

Slip-ring brushgear assembly

HOW TO SELECT FRAME SIZE

The following examples show how to select most economical frame size for some arduous duty cycle drives without refering to Marathon Electric office.

EXAMPLE : 1 - 250 Tonne Main Hoist Drive

DATA:

Total Hoist Load	Actual mass to be lifted including beam with laddie hook (250 tonne)+ weight of bottom block and wire rope (12 tonne) = 262 Tonnes
Hoisting Speed	0.1 m/Sec.
Combined efficiency of gear and rotating sheaves	$(0.95)^n \times (0.99)^m$ Where: n: Nos. of pair of gears= 3 m: Nos. of rotating sheaves = 4 $= (0.95)^3 \times (0.99)^4$ = 0.8236
Motor speed	= 585 r.p.m.
Load inertia referred to motor shaft = = 90 kgm2 Permanent slip in rotor circuit = 8% (maximum) Ambient Temperature = 55°C	
Duty	= 300 starts/hr: 60% CDF
Hoisting Force	= (262x9.81) KN = 257OKN
Hoisting power required	$\frac{\text{Hoisting Force (KN)} \times \text{Hoisting speed (m/sec)}}{\text{Hoisting Efficiency (p.u.)}} = 312\text{ KW}$
Taking account of deration factor of 0.83 for 55°C ambient temperature and 1.08 for 8% constant slip.	
Required power	$\frac{312 \times 1.08}{0.83} = 406\text{KW}$
With parallel operation of two motors and 10% margin for load sharing between two mechanically coupled motors, each motor should be capable of delivering 223 KW.	
Here KS500L could be a good option. KS450LB could also be considered as it can deliver 185 KW (300 starts/hr. 60% CDF) with a permissible total inertia (GD2) of (183.6+175) kg.m2 i.e. 358.6 kgm2.	
This motor with an output of 223 kw is suitable for a total intertia	
(GD^2) of $= \frac{185}{223} \times 358.6 = 297.5\text{ kgm}^2$	

EXAMPLE : 2 - Long Travel Drive

The selection of a motor for long travel drive requires careful calculation because of high load inertia. The motor must be capable of providing torque for acceleration to overcome the track rolling resistances, anti-friction and wind resistance, as applicable.

DATA:

Gross Mass to be moved

= Mass of crane structure (dead load) + actual mass to be moved (live load)
= 510 Tonnes + 225 Tonnes
= 735 Tonnes

Travel speed = 1.2m/sec.
Acceleration required = 0.2m/Sec2
Wheel diameter = 0.9m
Gear ratio = 28.5 : 1
Gear Efficiency $= (95)^n$ (n is No. of gear reduction).
$= (0.95)^3$
=.86

EXAMPLE : 2 - Long Travel Drive (Contd.)

Axle friction (Plain bearing)	315N/Tonne, at breakaway. 105N/Tonne at running. (if rolling bearings are used, 2/3rd of these figures to be considered) Duty= 300 starts/hour, 40% CDF. Amb. Temp. = 60°C. Motor Speed = 730 rpm.

(a) Determine track rolling resistance and total friction.

By definition - Rolling friction force

$= \frac{13}{\text{Wheel diameter}}$ N/tone

$= \frac{13}{0.9}$

= 14.5 N/tonne

Total frictional force at breakaway
= Axle friction force + Track rolling friction force
= (210 + 14.5) N/Tonne
= (224.5 x 735) N
= 165007 N

Total frictional force at running
= (70 + 14.5) N/tonne
= (84.5 x 735) N
= 62108 N

(b) Determine breakaway torque

Frictional torque at breakaway

$= \frac{\text{Total friction force (N)} \times \text{Wheels radius (m)}}{\text{Gear ratio} \times \text{Gear Efficiency}}$

$= \frac{165007 \times 0.45}{28.5 \times 0.86}$ Nm

= 3029 Nm

(c) Determine running torque and power

Running torque

$= \frac{\text{Total friction force (N)} \times \text{Wheels radius (m)}}{\text{Gear ratio} \times \text{Gear Efficiency}}$

$= \frac{62108 \times 0.45}{28.5 \times 0.86}$

= 1140 Nm

Running power

$= \frac{\text{Load torque (Nm)} \times \text{Speed (rpm)}}{9950}$

$= \frac{1140 \times 730}{9550}$

= 87.2 kW

Considering a deration of 0.75 for 60 Deg. C ambient, running power requirement

$= \frac{87.2}{0.75}$

= 116.3 kW

(d) Determine average run-up torque

Average accelerating torque to produce the acceleration required

$= \frac{\text{Rate of acceleration (m/sec}^2\text{)} \times \text{mass (kg)} \times \text{wheel radius (m)}}{\text{Gear ratio} \times \text{Gear efficiency}}$

$= \frac{0.2 \times 735 \times 1000 \times 0.45}{28.5 \times 0.86}$ Nm

= 2700 Nm

Average run-up torque
= Average accelerating torque + Running torque
= (2700 + 1140) Nm
= 3840 Nm

EXAMPLE : 2 - Long Travel Drive (Contd.)

(e) Determine load inertia referred to motor shaft

Parts in linear motion

I_L = mass (kg) x $\left(\frac{\text{Travel speed (m/sec)}}{2\pi \text{ x Motor speed (rps)}} \right)^2$

= 735 x 1000 x $\left(\frac{1.2 \times 60}{2 \times 730} \right)^2$

= 181.1 kg m^2

An allowance of 10% is normally considered for the inertia of rotating parts of the drive other than the rotor itself. Therefore, the total load inertia is:

Average accelerating torque + Running torque

I_L = (1.1 x 181.2) kgm^2

= 199.2 kgm^2

(f) Selecting the motor to suit the above conditions

(i) Check for breaking and accelerating torque.

The maximum torque (POT) available. T max must exceed the breakaway requirements, i.e. 3029 Nm (see calculation b), usually a safety factor of 20% is used.

Therefore:

T max ≥ 1.2 x 3029

= 3635 Nm

Also, T max available must exceed the run-up torque requirement. Normally, to allow for a stepped rotor resistance control, a maximum torque 70% higher than average accelerating torque is used.

T max ≥ (1.7 x 2700) Nm

= 4590 Nm

In some situation, where run-up torque is considerably high due to say wind loading it becomes necessary to ensure that there is a sufficient margin of torque (about 40%) above the average run-up torque.

T max ≥ (1.4 x 3840) Nm

= 5376 Nm

When plain bearings are used the higher breakaway torque will normally provide this margin. However, when roller bearings are used, the maximum torque may have to be increased, particularly when then number of rotor resistance steps are small.

Now the requirement here can be met with a single KS355SB motot (see table). If the mechanical drive conditions make it preferable to choose a twin motor drive then two KS315S2 motor could be selected.

EXAMPLE : 3 - Transfer Drive

DATA:

Load Torque	600 Nm.
Inertia of driven part (60 sq.)	52kg.mt.sq
Proposed motor speed	730 rpm (approx.)
Accelerating time	4 seconds
Plug braking time	2.5 seconds
Energised time (including above)	24 seconds
Total cycle time	40 seconds (repeated continuous)

(a) Determining starting class

Cycles per hour

= $\frac{\text{Seconds per hour}}{\text{Seconds per cycles}}$

= $\frac{3600}{40}$

= 90

Considering one accelearation and one plug braking per cycle:

Equivalent starts

= 90 + 90 x $\frac{80}{100}$

= 90 + 72

= 162

This is greater than 150 and less than 300; therefore the starting class is regarded as 300 starts/hour

EXAMPLE : 3 - Transfer Drive (Contd.)

(b) Determining cycle duration factor

CDF = $\frac{\text{Energised time}}{\text{Total cycle time}}$

= $\frac{24}{40}$ x 100

= 60%

(c) Determining power required

PL = $\frac{\text{Load Torque (Nm) x Speed (rpm)}}{9550}$

= $\frac{600 \times 730}{9550}$

= 45.9 kW

(d) Choose frame size

Rated outputs for starting class 300, 60% CDF, 8 pole near to 45.9KW is

Frame size - KS20MB...43 KW

Frame size - KS315S1...52KW

INERTIA CHECK

		KS280MB	KS315S1
Motor Inertia Im	=	17.5	23.5
Load Inertia IL	=	25.6	26.7
Total Inertia IT	=	43.1	50.2

At actual 162 equivalent starts instead of 300, the values of IT and IL can be modified as:

		KS280MB	KS315S1
Applying Rule 1 (IT)	=	43.1 x $\frac{300}{162}$	50.2 x $\frac{300}{162}$
	=	79.8kg.m^2	93g.m^2
(IL)	=	79.8 - 17.5	93.0 - 23.5
	=	62.3kg.m^2	69.5kg.m^2

Load GD^2 here is 52kg.m^2 which both motors can easily accommodate.

PULL OUT TORQUE CHECK

From KS motor table, POT values are as follows:

Frame KS250MB, T Max = 2506 Nm

Frame KS280SA1, T Max = 3114 Nm

Acceleration time

= $\frac{\text{Total Inertia (GD)}^2 \text{ x rpm}}{\text{375 x Accelerating torque (kg.mt.)}}$

If the average accelerating torque = load torque = 600 Nm

KS280MB	KS315S1
Ta = $\frac{(52 + 17.5) \times 730 \times 9.81}{375 \times 600}$ = 2.2 seconds	Ta = $\frac{(52 + 23.5) \times 730 \times 9.81}{375 \times 600}$ = 2.4 seconds

This is much less than the required 4 seconds accelerating time, so both motors have adequate torque capacity.

GUIDANCE ON RATING CATEGORIES

Based on Appendix A of "General code of practice for design of EOT cranes (Electrical Aspect) - IPSS:2-02-004-84 and " Rules for design of hoisting appliance" Part II Appendix A.2.13 published by the Fédération Européenne de la Manutention-1964

Type of Crane and Motion		Electric Motors	
		CDF %	Starting Class
1	Traveling crane for power station		
	Hoisting	15 - 25	150
	Aux. hoisting	15 - 25	150
	Cross traverse	15 - 25	150
	Long Travel	15 - 25	150
2	Overhead traveling crane for assembling and dismantling of machinery		
	Hoisting	15 - 25	150
	Aux. hoisting	15 - 25	150
	Cross traverse	15 - 25	150
	Long Travel	15 - 25	150
3	Overhead traveling crane for stores		
	Hoisting	25 - 40	150 - 300
	Aux. hoisting	25 - 40	150 - 300
	Cross traverse	25 - 40	150 - 300
	Long Travel	25 - 40	150 - 300
4	Overhead traveling crane for workshops		
	Hoisting	25 - 40	150 - 300
	Aux. hoisting	25 - 40	150 - 300
	Cross traverse	25 - 40	150 - 300
	Long Travel	25 - 40	150 - 300
5	Overhead traveling crane with grab		
	Hoisting	40 - 60	300
	Aux. hoisting	25 - 60	300
	Cross traverse	60	300
	Long Travel	40 - 60	300
6	Overhead traveling crane in scrapyard		
	Hoisting	40 - 60	150 - 300
	Aux. hoisting	25 - 60	150 - 300
	Cross traverse	40 - 60	150 - 300
	Long Travel	40 - 60	150 - 300
7	Overhead traveling crane with magnet for transporting plates and the like		
	Hoisting	40 - 60	150 - 300
	Aux. hoisting	25 - 40	150 - 300
	Cross traverse	40 - 60	150 - 300
	Long Travel	40 - 60	150 - 300
8	Steelworks or foundry ladle crane		
	Hoisting	40 - 60	300 - 600
	Aux. hoisting	40	300 - 600
	Cross traverse	40	300 - 600
	Aux. cross traverse	40	300 - 600
	Long Travel	40	300 - 600
9	Steelworks pig iron breaking crane		
	Hoisting	40 - 60	300 - 600
	Cross traverse	40	300
	Long Travel	40	150
10	Steelworks ingot stripper crane		
	Hoisting	60	600
	Aux. hoisting	25 - 40	300
	Cross traverse	60	300 - 600
	Closing motions for tongs	40	300
	Slewing motions	40	300
11	Steelworks soaking pit crane; ingot charging crane		
	Hoisting	60	600
	Aux. hoisting	25 - 40	300
	Cross traverse	60	300 - 600
	Closing motions for tongs	60	300 - 600
	Closing motions for tongs	40	300
	Slewing motions	40	300
12	Steelworks open hearth furnace charging crane		
	Hoisting	60	300 - 600
	Aux. hoisting	25 - 40	300
	Cross traverse	60	300 - 600
	Aux. cross traverse	40	300
	Long Travel	60	300 - 600
13	Steelworks forge crane with turning gear		
	Hoisting	60	300 - 600
	Cross traverse	60	300 - 600
	Long Travel	60	300 - 600
14	Bridge crane for hook duty		
	Hoisting	25 - 40	150
	Aux. hoisting	25 - 40	150
	Cross traverse	25 - 40	150
	Long Travel	25 - 40	150
15	Bridge crane with grab		
	Hoisting	40 - 60	300
	Closing	25 - 60	300
	Cross traverse	60	300
	Long Travel	40 - 60	300
16	Bridge crane used in a production cycle		
	Hoisting	40 - 60	300
	Cross traverse	40	300
	Long Travel	40 - 60	300

Note:

1. A cycle of 10 minutes must be adopted in the case of large heights and long hoisting times
2. Where the travel motion is used only for positioning, take cyclic duration factor as 25%

	Type of Crane and Motion	Electric Motors CDF %	Electric Motors Starting Class
17	Bridge crane for assembling and dismantling		
	Hoisting	15 - 25	150
	Aux. hoisting	15 - 25	150
	Cross traverse	15 - 25	150
	Long Travel	15 - 25	150
18	Jib crane for assembling and dismantling		
	Hoisting	15 - 25	150
	Aux. hoisting	15 - 25	150
	Jib luffing	25 - 40	150
	Slewing	15 - 25	150
	Long Travel	15 - 25	150
19	General purpose jib crane; cargo wharf crane		
	Hoisting	40	150
	Jib luffing	40	150
	Slewing	40	150
	Long Travel	25	150
20	Grabbing jib crane grabbing wharf crane		
	Hoisting	40 - 60	300
	Closing	25 - 60	300
	Jib luffing	40 - 60	300
	Slewing	40 - 60	300
	Long Travel	25 - 40	150
21	Shipyard jib crane		
	Hoisting	25 - 40	150
	Aux. hoisting	40	150
	Slewing	15 - 25	150
	Jib luffing	15 - 25	150
	Long Travel	25 - 40	150
22	Jib crane for exceptional service (heavy lift); floating crane		
	Hoisting	15 - 25	150
	Aux. hoisting	25 - 40	150
	Jib luffing	15 - 25	150
	Slewing	15 - 25	150
	Long Travel	15 - 25	150
23	Floating crane, general purpose		
	Hoisting	40	150
	Jib luffing	40	150
	Slewing	40	150
24	Floating crane, grab type		
	Hoisting	40 - 60	300
	Closing	25 - 60	300
	Jib luffing	40 - 60	300
	Slewing	40 - 60	300
25	Building jib crane		
	Hoisting	40 - 60	150 - 300
	Jib luffing	25 - 40	150
	Cross traverse	25 - 40	150
	Slewing	25 - 40	150
	Long travel	25 - 40	150

	Type of Crane and Motion	Electric Motors CDF %	Electric Motors Starting Class
26	Railway breakdown crane		
	Hoisting	25 - 40	150
	Jib luffing	25 - 40	150
	Cross traverse	25 - 40	150
	Slewing	15 - 25	150
	Long travel	15 - 25	150
27	Derrick crane sheerlegs		
	Hoisting	15 - 25	150
	Jib luffing	15 - 25	150
	Slewing	15 - 25	150
28	Deck crane cargo-handling		
	Hoisting	25	150
	Jib luffing	25	150
	Slewing	25	150
29	Deck crane, grab type		
	Hoisting	25 - 40	300
	Closing	25 - 40	300
	Jib luffing	25 - 40	300
	Slewing	25 - 40	300

SOME USEFUL CONVERSIONS

The constants which appear below are provided for use in any conversions which may prove necessary in order to carry out frame size selection calculations.

	to convert	to		
Length	ft	m	multiply by	0.3048
Speed	ft/sec	m/s		0.3048
Acceleration	ft/sec^2	m/s^2		0.3048
Mass	ton	tonne		0.9842
	lb	kg		0.4536
Force	lbf	N		4.4482
	kgf	N		9.8067
	kilopond	kgf		1.0000
Torque	lbt ft	Nm		1.3558
	kgf m	Nm		9.8067
Power	hp	kw		0.7457
Inertia	lb ft^2 (mr^2)	kg m^2 (mr^2)		0.04214
	lb ft^2 (WR^2)	lb ft^2 (mr^2)		1,000
	lb ft^2 (mr^2)	kg m^2 (GD^2)		0.16856
	Slug ft^2 (mr^2)	lb ft^2 (mr^2)		32.174
	Slug ft^2 (mr^2)	kg m^2 (mr^2)		1,3558
Temperature interval	°Celsius	Kelvin		1,000
	°Fahrenheit	K		5/9
Temperature	°C	K	add	273.15
	°F	°C	subtract 32 and multiply by 5/9	

NOTES:

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The values shown are subject to change without prior notice.
The information contained is reference values.