RULES FOR THE DESIGN OF HOISTING APPLIANCES

BOOKLET 5

ELECTRICAL EQUIPMENT

The total 3rd Edition revised comprises booklets 1 to 5 and 7 to 9

Also available in French and German

Document prepared by the technical commission of **FEM** (European Handling Federation) **Section I** « Heavy lifting and handling equipment ».

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The third edition of the "Rules for the design of hoisting appliances" dated 1987.10.01[1] included 8 booklets. An addition to this edition was compiled in 1998. This addition is incorporated in booklet 9, which also replaces booklet 6.

This booklet forms part of the "Rules for the design of hoisting appliances" 3rd edition revised, consisting of 8 booklets :

Booklet 1 - Object and scope

Booklet 2 - Classification and loading on structures and mechanisms

Booklet 3 - Calculating the stresses in structures

Booklet 4 - Checking for fatigue and choice of mechanism components

Booklet 5 - Electrical equipment

~~Booklet 6 - Stability and safety against movement by the wind~~

Booklet 7 - Safety rules

Booklet 8 - Test loads and tolerances

Booklet 9 - Supplements and comments to booklets 1 to 8

NOTE: Booklet 9 must not therefore be used separately.

[1] The item 5.8 « SELECTION OF MOTORS » was rewrite in 1992 in order to allow crane manufacturers to design motors, as precisely as possible.

Item 5.8 is devided into 3 parts :

1rst part (5.8.1) : General determinations for the selection of motors and dimensionning of motors according to thermal aspects, usually applying on all sorts of drives in intermittent service.
In this part, the item 5.8.1.4 « SQUIRREL-CAGE MOTOR » includes a method to calculate; suitable for asynchronous squirrel cage motor.
This method, given on a trial basis, has to be tested.

2nd part (5.8.2) : Special determinations to dimension motors according to the maximum torque required for LIFTING motions and according to data on stress occuring during the use of these drives.

3rd part (5.8.3) : As in 2nd part, but this item applies on motors for HORIZONTAL motions.

BOOKLET 5

ELECTRICAL EQUIPMENT

SUMMARY

5.1. **FOREWORD**

The electrical equipment for lifting appliances should conform to the applicable CENELEC standards. In the event of there being no applicable CENELEC standard the following recommendations apply.

5.2. POWER SUPPLY

5.2.1. CHARACTERISTICS OF POWER SUPPLY SYSTEM

5.2.1.1. VOLTAGE

This document deals with low-voltage alternating current standardized power supply systems (< 1000 V).

5.2.1.2. VOLTAGE DROP

Voltage variation at the connection point of the supply line to the system should not exceed $\pm$ 5 % of its rated value, under normal operating conditions.

5.2.2. CUT-OUT AND SAFETY DEVICES BETWEEN SUPPLY SYSTEM AND SUPPLY LINES

- The power supply system should be switched off by switches connected to supply (live cut-out) ; these devices should be rated for the fault level of the supply. Fused switches or circuit breakers can equally be used for this function.

- Sector connection switches should be made available at easily accessible points within the lifting equipment area or should be remote-controlled. It is necessary for quick access to them to be possible.

  For portal cranes with enclosed conductor systems, or trailing cables, main isolating switches need not be fitted on the cranes. Also the requirement for quick access can be dispensed with if the crane can be de-energised from quay level.

- In the case of multiple supply to one contact line, each supply should be fitted with a switch (or contactor) connecting the supply : all of these supply connection switches should be released simultaneously when even a single switch is operated.

- Re-connection of a supply system with multiple supply should only be possible from a single point. Supply connection switches along with their release points (control devices) should be marked as such. For example : supply connection switch for hoisting appliance no. ...

- Supply connection switches and control equipment for re-connection should be equipped with safeguards against any errors of unauthorized tripping.

5.2.3. SUPPLY SYSTEMS

5.2.3.1. CONDUCTOR BARS - CABLE REELS

5.2.3.1.1. **Safety conductor and current collectors (earth)**

For supplies powered by contact lines or collectors, an easily identifiable conductor bar or collector ring should be provided for the safety circuit ; the safety protective conductor should not be used as an active conductor.

Hoisting appliances should be connected to the safety conductor via sliding collector shoes.

Runners, rollers or any other roller systems must not be used as connections for the safety conductor.

The current pick-ups for the safety conductors should be designed in such a way that they cannot be interchanged with the pick-ups for active conductors.

5.2.3.1.2. **Arrangement**

Conductor bars should be arranged or insulated with covering in such a way that no accidental contact is possible. For example : when gaining access to, or walking on, the gangways or platforms of the lifting equipment.

The conductors should be so arranged that lifting tackle does not make contact with them even in the event of swinging of the load.

5.2.3.1.3. **Minimum gaps**

The minimum gap between live parts, and between live and earth parts should be guaranteed to be at least 10 mm at the conductor bars in the case of positive guidance between the conductor bars and the current pick-up. For equipment which is built and checked in the works and for operational voltages less than or equal to 500 V, a gap of 6 mm is sufficient.

If guidance is not of the positive type, the gap should be so selected that there is a minimum gap of 10 mm.

5.2.3.2. **FLEXIBLE SUPPLY CABLES**

Flexible supply cables should be arranged and should move in such a way that wear and tear is avoided. Winding drums should be designed in such a way that the inner diameter of the drum is at least 10 times the outer diameter of the cable for cables up to 21.5 mm diameter and at least 12.5 times the outer diameter of the cable for cables whose outer diameter is greater than 21.5 mm.

In the case of festoon-cable trolleys for cables of outer diameter up to 8 mm, the inner curvature diameter should be at least 6.3 times the outer diameter of the cable. For cables with outer diameters greater than 8 mm, this should be at least 8 times the outer diameter. For cables with an outer diameter greater than 12.5 mm, this should be at least 10 times the outer diameter.

In the case of flat cables, the thickness of the cable corresponds to the diameter of circular cables.

The constant tractive force acting on the conductor should be as low as possible. With non-reinforced, symmetrical cable, this should be a maximum of 20 N/mm^2 applied to the total copper section of the whole of the conductors.

Where the cable is moved at high speed or is of considerable weight, all necessary steps must be taken to prevent the cables from being excessively stressed.

The cable winders should wind up the cable automatically.

5.2.3.3. CALCULATION OF CONDUCTOR BARS

Cross-sections of the conductor bars are determined :

- as a function of the maximum thermal intensity admissible,
- as a function of the maximum voltage drop admissible.

These two conditions each provide a minimum cross-section, the larger being the one to be selected.

5.2.3.3.1. Calculation of the minimum cross-section in relation to the current intensity and the thermal capacity of the line

The minimum cross-sections in relation to the intensities are stated in the manufacturer's catalogue.

When calculating the cross-section in relation to the rated thermal intensity I_N admissible for the conductor bar which supplies several hoisting appliances, the actual simultaneous operation of the drive motors must be taken into account. In the absence of this information, see table T.5.2.3.3.1.

Table T.5.2.3.3.1.

	For all lifting appliances as a whole (I_N)			
	1st motor	2nd motor	3rd motor	4th motor
Number of hoisting appliances on one main contact line	most powerful motor (1)	Motors in decreasing order of power (1)		
1	X	X		
2	X	X	X	
3	X	X	X	
4	X	X	X	X
5	X	X	X	X
Two hoisting appliances working together	X	X	X	X

(1) For drive by n motors in parallel, consider : $I_N = n \times I_{N'}$

$I_{N'}$ = Nominal current for one motor.

5.2.3.3.2. Calculation of the cross-section in relation to the admissible voltage drop

When calculating the voltage drop, the most unfavourable position of the hoisting appliance in relation to the supply point must be considered.

When calculating the admissible voltage drop on a supply line used by several hoisting appliances, the start-up and rated current intensities of the motors operating simultaneously must be taken into account. In the absence of precise details, refer to table T.5.2.3.3.2.

Table T.5.2.3.3.2.

Number of appliances on one main contact line	For all the hoisting appliances as a whole							
	1st motor		2nd motor		3rd motor		4th motor	
	I_D	I_N	I_D	I_N	I_D	I_N	I_D	I_N
1	X			X				
2	X			X		X		
3	X		X					
4	X		X			X		
5	X		X			X		X
2 appliances working together	X		X			X		X

For squirrel-cage rotor motors' I_D (start-up current intensity), refer to the manufacturer's catalogue.

For slip-ring rotor motors, consider I_D to be approx. equal to $2 \times I_N$.

For drive by n motors in parallel, consider : $n \times I_D$ or $n \times I_N$.

The motors should be arranged in the table in accordance with their start-up current intensity (I_D).

Calculation of three-phase section

$$S = \frac{\sqrt{3} \cdot \ell \cdot I_{tot} \cdot \cos\varphi}{\Delta u \cdot \kappa} \quad (1) \quad (mm^2)$$

S = Cross-section in mm^2

ℓ = Effective length of the line in m

I_{tot} = Sum of I_D and I_N currents according in ampère

Δu = Admissible voltage drop in volts

κ = Electric conductivity in $\frac{m}{\Omega \cdot mm^2}$

$\cos\varphi$ = Power factor

5.3. INSTALLATION OF CABLES AND CONDUCTORS

5.3.1. SELECTION OF CABLES AND CONDUCTORS

The cables and conductors must have the characteristics described in the CENELEC publications HD 21, HD 22, HD 359 and HD 360 or at least the equivalent.

Flexible cable for the cabling of hoisting appliances including cables for reels should preferably be selected from the H 07 RN-F U_o/U-450/750 or H 07 VV-F U_o/U-450/750 or H 07 RN-H series.

Rigid conductors fitted to the lifting apparatus should preferably be selected from the H 07 VV-U or H 07 VV-R or H 07 RN-U or H 07 RN-R series.

Bare wires and conductors can only be used for internal wiring cabinets and special electric enclosed spaces.

For circuits with rated voltage of less than 250 V between conductors or between conductor and earth, cables with a rated voltage U_o/U = 300/500 V may be used.

5.3.2. CALCULATION OF CROSS-SECTION OF CONDUCTORS

The cross-section of the conductors should be determined by taking into account the mechanical strength required and the electrical load to be carried.

For regular service, the voltage drop must be considered.

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(1) Take inductive reactance into account for very long lines.

The cross-section of the conductors should be determined by taking into account :

- the thermal capacity of the conductors in accordance with table T.5.3.2. for example :

Table T.5.3.2.

Cross sectional area mm^2	Permissible Current for Insulated Conductors at Ambient Temperature 40°C for a Duty Factor of : 100 % A	60 % A	40 % A
1,5	18	18	20
2,5	26	26	30
4	34	34	40
6	44	44	50
10	61	61	75
16	82	87	105
25	108	120	145
35	135	145	175
50	168	180	210
70	207	240	270
95	250	270	330
120	292	310	380
150	335	350	430

- Calculation of the voltage drop :

$\Delta u = \sqrt{3}\, \ell\, I\, [r \cos\varphi + x \sin\varphi]$

Δu = voltage drop

ℓ = length

I = starting current of the motor

r = resistance per length unit

x = reactance per length unit.

Minimum admissible cross sectional area of copper conductors:

- 1,5 mm^2 for multi strand conductors,
- 0,75 mm^2 for flexible conductors with shielding,
- 0,25 mm^2 for flexible conductors between electronic components.

Conductors with solid cores are not accepted.

5.3.3. INSTALLATION CONDITIONS

Type of protection for connection and distribution equipments must be suitable for surrounding conditions, minimum degree of protection being at least IP 43 of IEC 144.

The connections and linking terminals should be placed in cabinets or boxes.

Connection terminals whose accidental connection could be dangerous should be clearly separated unless their design precludes this risk.

In order to ensure continual mechanical protection, the protective covering of the cables and conductors should enter housings through packing glands or such similar devices.

The wires or conductors belonging to electrical circuits with different rated voltages may be arranged within a single enclosure or may form part of the same cable provided that these wires or conductors are insulated against the highest rated voltage.

Conductors having single insulation can only be installed in conduits or trunking whose ends are fitted with adequate protection.

Non-sheathed conductors and cables which are fixed to parts of the framework should be protected, if necessary, against any mechanical wear and tear.

5.4. ELECTRICAL PROTECTIVE AND SAFETY EQUIPMENT

5.4.1. SAFEGUARDING MOTORS

5.4.1.1. MOTORS USED IN CONTINUOUS DUTY OR SHORT TIME DUTY (S1 - S2 AS PER IEC 341)

In this case, for example, protection may be afforded :

- either by suitably arranged thermal sensors within the motor,
- or by inverse time magnetic relay or timed thermal relay placed in each of the supply phases.

5.4.1.2. MOTORS USED IN INTERMITTENT DUTY (S3 - S8 DUTY AS PER IEC 341)

When the duty cycle, time and load are known and the motor is rated accordingly, safeguarding against overloads is not necessary.

5.4.2. SAFEGUARDING WIRING

The cross-section of a conductor should be determined according to the current intensity to which it is subject during both normal running of the motor and starting-up or electrical braking.

Whether the load is protected or not, all wires should be safeguarded against any overcurrent, which could result from a short-circuit or faulty insulation.

The protective device shall be rated for the appropriate short-circuit level anticipated.

5.4.3. SAFEGUARDING AGAINST ABSENCE OR INVERSION OF PHASES

When starting, the correct phase rotation must be ensured. If the absence of phases may occasion a danger, the appropriate safety measures must be taken.

5.4.4. ACTION OF SAFETY DEVICES

When several motors drive the same motion, the action of a safety device should stop all of the motors for this movement.

After a safety device has been activated, it should only be possible for the equipment to be started up again manually.

5.4.5. PROTECTION AGAINST THE EFFECTS OF LIGHTNING

For very tall pieces of hoisting equipment which are erected in particularly exposed locations, the effects of lightning must be considered

1. on pieces of vulnerable structure (for example : jib support cable)
2. on anti-friction bearings or runners which form a link between large parts of the frame (for example : slewing ring, travel runner).

When this is necessary, safeguarding against the effects of lightning should be carried out following IEC TC 81.

For the safety of personnel, it is recommended that the runner rails for the lifting equipment are earthed.

5.5. END LIMIT SWITCHES

5.5.1. LIMIT SWITCHES

The motorized motions of hoisting apparatus described in paragraphs 5.5.1.1. to 5.5.1.4., should be equipped at the minimum with a limit switch with automatic cut-out which safely prevents the end positions from being over-run. It acts only as a safety limit and not as a drive element. When the limit switches operate electrical circuits they shall satifsfy for each mechanism the following conditions.

5.5.1.1. HOIST MECHANISM

- Hoisting motion over hoist position,
- Lowering motion over lower position for rope appliances if, with the hook on the ground, there is less than 2 turns of rope remaining on the drum.

5.5.1.2. DERRICKING MECHANISM (MAIN JIB, AUXILIARY JIB, BRIDGE CRANE BOOM)

- Derricking motion (highest admissible position)
- Lowering motion (lowest admissible position) ; in certain cases, this function may be carried out by a moment limiter.

5.5.1.3. CROSS TRAVEL, LONG TRAVEL AND DISTRIBUTION MECHANISM

If the travel or cross motion is driven from a fixed control point, by means of remote control or radio control, these movements must be automatically limited.

In the case of a crane equiped with trolley travel on a jib with the exception of wall cranes, the trolley's movement must be safety limited as soon as the end positions are reached. These limit switches are not necessary for friction drive, if the trolley travel speed is less than or equal to 0.4 m/s and if the working load is less than 1000 kg.

5.5.1.4. SLEWING MECHANISM

If the use of equipment outside an authorized zone presents any risks, it should be equipped with a limit switch.

5.5.2. LOAD AND LOAD MOMENT LIMITERS

If the lifting appliance is fitted with a load or load moment limiter and if designed for electrical operation, they shall satisfy the following technical conditions.

5.5.3. TECHNICAL OPERATION CONDITIONS

The positioning or operational limit switch should neither stop masses in motion, nor present extreme stress to part or all of the hoisting equipment.

A limit switch should bring about the arrest of motion by opening the electric circuit and keeping it open as long as safety conditions are not restored.

A limit switch should be equipped with a safety device.

These safety devices should be :

- either with a positively acting mechanism and driven with the least number of intermediary parts possible.
- or quick-break contacts (blade contacts, micro-switches). In this case the circuit in which the contact is inserted should be protected against short circuits in order to ensure that the contacts do not weld together.
- or by static systems (electronics) e.g. : proximity switches.

If it is unavoidable to by-pass a safety device, this operation should only be able to be effected with the aid of a device which, when no longer actuated, automatically re-inserts the safety device.

After operation of an automatic limiter, movement in the opposite direction must always remain possible.

Housings for limiters installed in dry places must conform to safety factor IP 43 at least. Housings for limiters installed in humid places or out of doors should conform to safety factor IP 55 at least.

Ambient temperatures should not affect operation of the limiter.

Temperature ranges are :

- indoor : 0° C to + 40° C
- outdoor : - 30° C to + 40° C

5.6. CONTROLS

5.6.1. COMPONENTS

5.6.1.1. RELAYS AND CONTACTORS

Relays and contactors must comply with the requirements of IEC 158-1 and IEC 158-1A, especially section 4.3.6. with regard to the category of use.

In case the crane will be used at an altitude in excess of 1000 m, this shall be considered by selecting the contactors and relays.

Reversing contactors should be of the electrically or mechanically interlocking type.

The lifting appliance can only be energised when all the control devices are in the off position. This off position can be determined either by a checking circuit or by using a spring return.

5.6.1.2. RESISTOR UNITS

Resistor units, which are installed outside of electrical appliance rooms, should be accommodated in suitable, protected housings, as a minimum of IP 10 for indoor use and IP 13 for outdoor use as defined in IEC 144.

Liquid resistors shall not be used.

The temperature limit is determined by the resistor material. When designing the resistor units, the equivalent torque, cyclic duration factor and switching rate have to be considered.

5.6.2. ENCLOSURE OF HOUSINGS AND CABINETS

Switching devices, switchgear and panels housing electrical equipment may be enclosed as follows :

- in cabinets or housings,
- in special enclosed spaces,
- in the supporting structure (principally the crane girder) of the hoisting appliance.

5.6.2.1. HOUSINGS AND CABINETS

If separate housings and cabinets are used, they should be robust and have minimum degrees of protection of IP 43 for indoor operation and IP 55 for outdoor operation.

Housings and cabinets should be provided with doors or a cover.

If the doors carry electrical equipment, the doors, or the electrical equipment, should be earthed by a separate conductor.

The doors or covers should be lockable when closed.

There should be a clear space of at least 400 mm in front of housings and cabinets ; the floor should be free of obstacles and be sufficiently strong.

5.6.3. TYPE OF CONTROL

5.6.3.1. ISOLATION

The lifting appliance should be provided with an isolator which can be locked in the open position. When several appliances are on the same supply, it is necessary to install a lockable isolator on each appliance.

5.6.3.2. PERFORMANCE OF CONTROL SYSTEMS

The control system should be so designed that loads of up to 120 % of the nominal load of the hoisting appliance may be moved safely.

Lifting of a full load at 0.95 of rated voltage should not result in lowering of the load, whatever the position of the control lever.

Lowering of a full load should not be possible at more than 120 % of the nominal speed, whatever the position of the control lever, unless permitted by the control scheme.

For travelling and slewing units, starting and braking should be progressive in both directions.

5.6.3.3. CONTROL CIRCUIT

If the control circuit is fed by a transformer (or transformer with rectifier), the secondary voltage should not exceed 250 V. Safety has to be ensured against incorrect motion caused by insulation failure either in connecting the common polarity to the equipotential connection of the mass, or by an equivalent measure, as for example an insulation monitoring device.

This pole shall not be interrupted by any switch, contact or fuse. Suitable measures should be taken to protect the other pole against overloads or short-circuits.

If the control circuit is not fed by a transformer, equivalent safety measures should be taken.

5.6.4. TYPE OF CONTROL

5.6.4.1. ENERGISATION

The lifting appliance can only be energised when all the control devices are in the off position. This off position can be determined either by a checking circuit or by using a spring return.

5.6.4.2. **CAB CONTROL**

- The controls should be so arranged that the operator has an adequate view of the crane's working area.

- The control for hoisting appliances should preferably be arranged on the right-hand side of the operator's seat.

- As an emergency cut-out for all motions, a red-push button switch should be located in an easily accessible position on the control unit. This push-button switch should be of the mechanically unlocking type.

5.6.4.3. **FLOOR CONTROL**

Push-buttons or other switching devices, which automatically return to their "off" position as soon as they are released, should be provided for the control of all motions by pendant control units. In addition to the controllers, a device for opening and closing the main contactor must be provided (as described in 5.6.4.2.).

Except in the case of the direct-on-line control of motors, the voltage in pendant control units should not exceed 250 V.

Housings of pendant control units should preferably be of fully insulating material or of material with protective insulation. Metal parts accessible from the outside, which pass through the insulation, should be separately earthed.

The surface of the housing must be a vivid colour. For indoor operation, the degree of protection should be IP 43 at least, and for outdoor operation IP 55 at least, as per IEC 144.

Pendant control units should be suspended with a strain relief arrangement.

5.6.4.4. **RADIO CONTROL**

For the radio control of a crane, safety should be assured :

- The system used should be of the "fail-safe" type, and the receiver should only respond to the one code of the transmitter corresponding to each hoisting appliance.

- In addition to the controllers for all motions, a device for switching the main contactor on and off should be provided.

- Motions should be controlled by push-buttons or switches which are provided with an automatic spring return to the "off" position. Control levers should be provided either with a mechanical device for locking in the "off" position or with a deadman's handle circuit.

The transmitter must have a minimum protection class IP 43 for indoor use and IP 55 for outdoor use.

5.6.4.5. **MULTIPLE CONTROL**

When duplicate controls are required for the hoisting appliance, only one control is to be in operation at any one time (e.g. : cab-control or floor control).

5.6.5. CONTROL OF MECHANICAL BRAKES

5.6.5.1. BRAKE CONNECTED DIRECTLY TO THE MOTOR

The brake circuit should be protected by a device which switches off the motor and brake in the event of a malfunction.

If the conductor to the brake is $\leqslant$ 5 m, this protection of brake is no longer necessary.

5.6.5.2. BRAKE CONNECTED SEPARATELY FROM THE MOTOR

Precautions should be taken so that it is not possible for any uncontrolled movements to occur before the brake operation is completed during starting and stopping.

Where there is electrical braking, the mechanical brake should be applied only after electrical braking.

Except for transitory conditions the brake must not be applied when the motor is energised.

5.6.5.3. AUXILIARY BRAKE

Cranes which require particular safety, e.g. in steel works or with dangerous or melted loads, should be provided with an auxiliary brake.

Under normal operating conditions, the auxiliary brake should always be applied on stopping, after the motion has been brought to a halt by the main brake. It must be possible to adjust this delay.

In the event of an emergency stop, the auxiliary brake should be applied immediately.

5.7. ENVIRONMENT

5.7.1. OIL DRIPS

No part of any lubricating or hydraulic system or other equipment containing oil shall be run or installed in such a position as to be able to cause oil drips onto the electrical equipment unless the equipment is protected from damage from this cause.

5.7.2. AMBIENT TEMPERATURE

All electrical equipment shall be suitable for operating continuously in an ambient temperature of - 20° to + 40° C. When the electrical equipment is installed in enclosed spaces (or crane girders), means shall be provided for ensuring that the permissible temperatures for the proper functioning of the electrical equipment are maintained.

However, if lower or higher ambient temperatures are envisaged, the user shall specify the temperature he requires the crane to work in and under these conditions the equipment may either be designed for the specified temperature or alternatively, heating or cooling may be provided.

5.7.3. HUMIDITY

All electrical equipment shall be suitable for use in atmospheres with an average relative humidity of up to 80 %. If the humidity is expected to exceed this level, special precautions should be taken which may include the provision of anti-condensation heaters and the varnishing of vulnerable parts.

These details shall be by agreement between the purchaser and the manufacturer.

5.7.4. DEGREE OF PROTECTION

The minimum degree of protection has been specified in other chapters in this document for specific items of installation. In the event that a higher or complementary degree of protection against dust is required by a particular installation environment, it should be agreed between the purchaser and manufacturer.

5.8 SELECTION OF MOTORS

5.8.1. CRITERIA FOR MOTOR SELECTION (IEC 34-1)

- required powers-the thermal power is also included in these required powers,
- maximum rated torque and maximum acceleration torque,
- cyclic duration factor,
- number of cycles/hour,
- type of control (type of braking), }
- speed regulation, }
- type of power feed, } driving systems
- degree of protection, (environment conditions), }
- ambient temperature,
- altitude,

For the predimensioning of the motor, account has to be taken of :

- the thermal calculation as per clause 5.8.1.3.
- the maximum required torque :
  - . for hoisting mechanisms as per clause 5.8.2.1.
  - . for horizontal motions as per clause 5.8.3.1.

The motor has to comply with the two requirements.

If the required torque diagrams, in order to define the mean equivalent torque (as per 5.8.1.3.1.) are not available, these can be assessed respectively with the help of tables T 5.8.2.2a. and T 5.8.3.2a

5.8.1.1. Remarks on the selection of motors

The selection of the motor should be agreed with the manufacturer in taking into account the torque and powers calculated in the following clauses and the real operating conditions of the motor.

In the event of electronic power control, the definition of the motors has to be made in cooperation with the manufacturer, taking into account the cooling system and the speed range.

5.8.1.2. Degree of protection (IEC 34-5)

5.8.1.2.1. Indoor application

For indoor application, under normal conditions, motors must comply wtih IP 23 at least.

In dusty environment, motors must comply with IP 44 at least.

5.8.1.2.2. Outdoor application

For outdoor application, motors must comply with IP 54 at least.
In case of water condensation risk, care should be taken that the water condensation drain holes remain open.

5.8.1.2.3. Particular application

Motors may comply with a lower degree of protection il they are appropriately protected, or protected by external means for their particular application.

5.8.1.2.4. Explosive environments

In potentially explosive environments, motors must be explosion-proof as EN 50014-50020.

5.8.1.3. Thermal calculation of the motor

5.8.1.3.1. Mean equivalent torque

In order to carry out the thermal calculation, the mean equivalent torque must be determined as a function of the required torque during the working cycles, by the formula :

$$M_{med} = \sqrt{\frac{M_1^2 t_1 + M_2^2 t_2 + M_3^2 t_3 + \ldots + M_n^2 t_n}{t_1 + t_2 + t_3 + \ldots + t_n}}$$

Where :

$t_1, t_2, t_3, \ldots t_n$ are the periods during which the different torque values are produced ; periods of rest are not taken into account.

$M_1, M_2, M_3, \ldots M_n$ are the calculated torque values, in taking into account all the inertia forces including the one of the rotor mass of the motor.

In case of variable loads, at least a maximum of 10 successive working cycles for the predimensioning, must be taken into account (see definition 2.1.2.2.).

Diagram 5.8.1.3.1. shows an example of the torque operation for 2 different cycles.

5.8.1.3.2. Mean equivalent power

Starting from the mean equivalent torque, the mean equivalent power P_{med} in kW is defined by the formula :

$$P_{med} = \frac{M_{med} \cdot n}{9\,550}$$

where :

M_{med} = mean equivalent torque in Nm
n = speed of motor in mn^{-1}

The such defined motor can be selected in S3 duty if one single motion operation is not exceeding 10 minutes. Should this not be the case, a special study has to be made.

For the squirrel cage motors, the predimensioning will be carried out according to the method described in clause 5.8.1.4..

For the motor selection, the mean equivalent power P_{med} should be corrected as a function of altitude if it exceeds 1000 m and the ambient temperature if it deviates from 40 °C (See 5.8.1.5.).

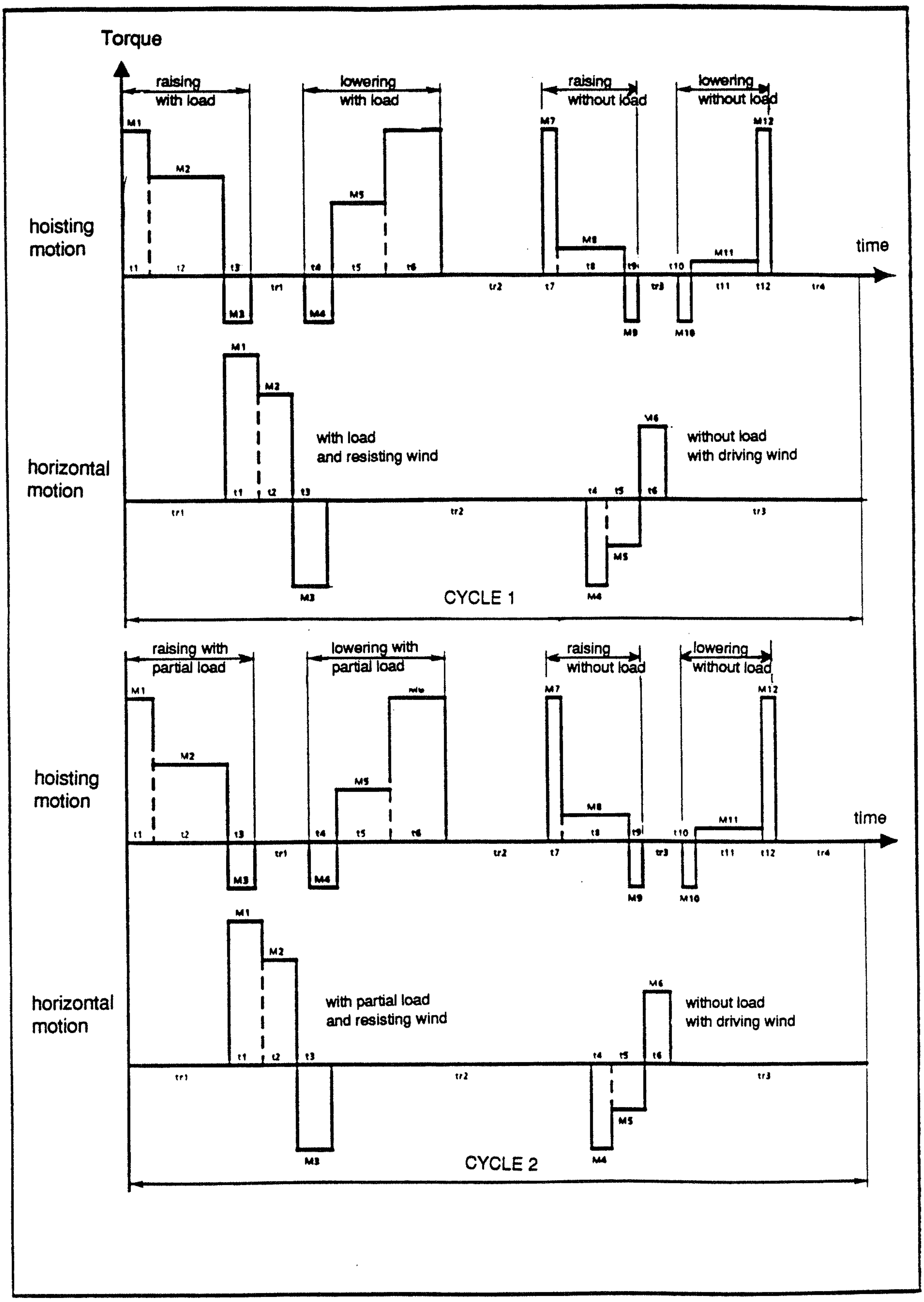

Diagram 5.8.1.3.1.

Typical operation of torque for 2 different cycles :

Hoisting motion		Horizontal motion	
tr : rest time		tr : rest time	
M1, M4, M7, M10,	starting torque	M1, M4	starting torque
M2, M8,	hoisting torque raising	M2,	working torque
M3, M6, M9, M12	braking torque	M3, M6,	braking torque
M5, M11,	hoisting torque lowering	M5,	torque without load with wind

5.8.1.4. Squirrel cage motor

The following inequality has to be checked for the predimensioning of the squirrel cage motors :

$$(C_k (1-\eta_N) . P_N . T > (1-\eta\ moy)\ P_{moy} . t_N + (P_N \frac{I_D}{I_N} . t_E - \frac{Jn^2\ moy . 10^{-3}}{180})$$

$(1 - \eta_N)\ P_N . T =$ loss energy ot the motor working at its rated power (S1) during a time T

$(1 - \eta_{moy}) . P_{moy} . t_N =$ loss energy of the motor during the time t_N (constant speed) in a cycle

$(P\ moy \frac{I_D}{I_N}\ t_E - \frac{Jn^2\ moy . 10^{-3}}{180}) =$ loss energy ot the motor during the starting and braking phases,

$C_k =$ correction factor linked to the type of motor

$P_N =$ nominal power in KW of the motor in continuous (S1) duty

$K_N =$ efficiency of the motor at P_N

$$P_{moy.} = \frac{M_{moy.}\ n_{moy}}{9550}$$

$n_{moy} =$ speed of motor for power p_{moy} in mn^{-1}

$M_{moy} =$ mean resisting torque in Nm calculated in the same manner as M_{med} in removing the starting and braking phases.

$\eta_{moy} =$ efficiency of the motor at power P_{moy}

$T =$ total time of cycle in s.

$$T = t_N + t_E + t_{stop} \qquad \frac{t_N + t_E}{T} = \frac{ED}{100}$$

$t_N =$ operating time at constant speed during one cycle in s.

$t_E =$ equivalent time of starting and braking during one cycle in s.

$$t_E = \frac{\pi}{30} . n_{moy} . \frac{J}{M_{acc}} : (d_{ccy} + 0,5\ d_{icy} + 3\ f_{cy})$$

$J =$ total inertia of masses in motion referred to the motor shaft in kg m²

$d_{ccy} =$ the number of complete starts during one cycle

$d_{icy} =$ the number of impulses during one cycle

$f_{cy} =$ the number of electrical brakings during one cycle

$M_{acc} =$ the mean accelerating torque in Nm

$$M_{acc} = M_{dmoy} - M_{moy}$$

M_{Dmoy} = mean starting torque of motor in Nm

The following data has to be indicated by the motor manufacturer :

P_N = nominal power (kW) of motor in continuous (S1) duty

1/4 ...5/4 = efficiency for 1/4 P_N ...5/4 P_N powers

J_M = moment of inertia of motor in kg m²

n 1/4 ...5/4 = speed of motor at 1/4 P_N ...5/4 P_N in nm-1

M_{Dmoy} = mean starting torque of motor in Nm

I_D/I_N = ratio between the starting current and the current at P_N

C_K = correction factor linked to the type of motor

In case the C_k factor is not mentioned in the manufacturer's catalogue, C_k shall be taken equal to 1 for motors of polarity equal or above 4.

5.8.1.5 Power correction in function of ambient temperature and altitude

These corrections are depending from the type of motor, the cooling method and the insulation class.

The precise calculation can only be made by the motor manufacturer in supplying them with the following indications :

- P_{med} without correction
- value of ambient temperature
- altitude

The predimensioning can be based on the values indicated in Diagram 5.8.1.5 in using the formula :

$$P'_{med} = \frac{P_{med}}{k}$$

or

$$P'_{moy} = \frac{P_{moy}}{k} \quad \text{for squirrel cage motors}$$

P'_{moy} or P'_{med} = required nominal power of motor as function of altitude and ambient temperature.

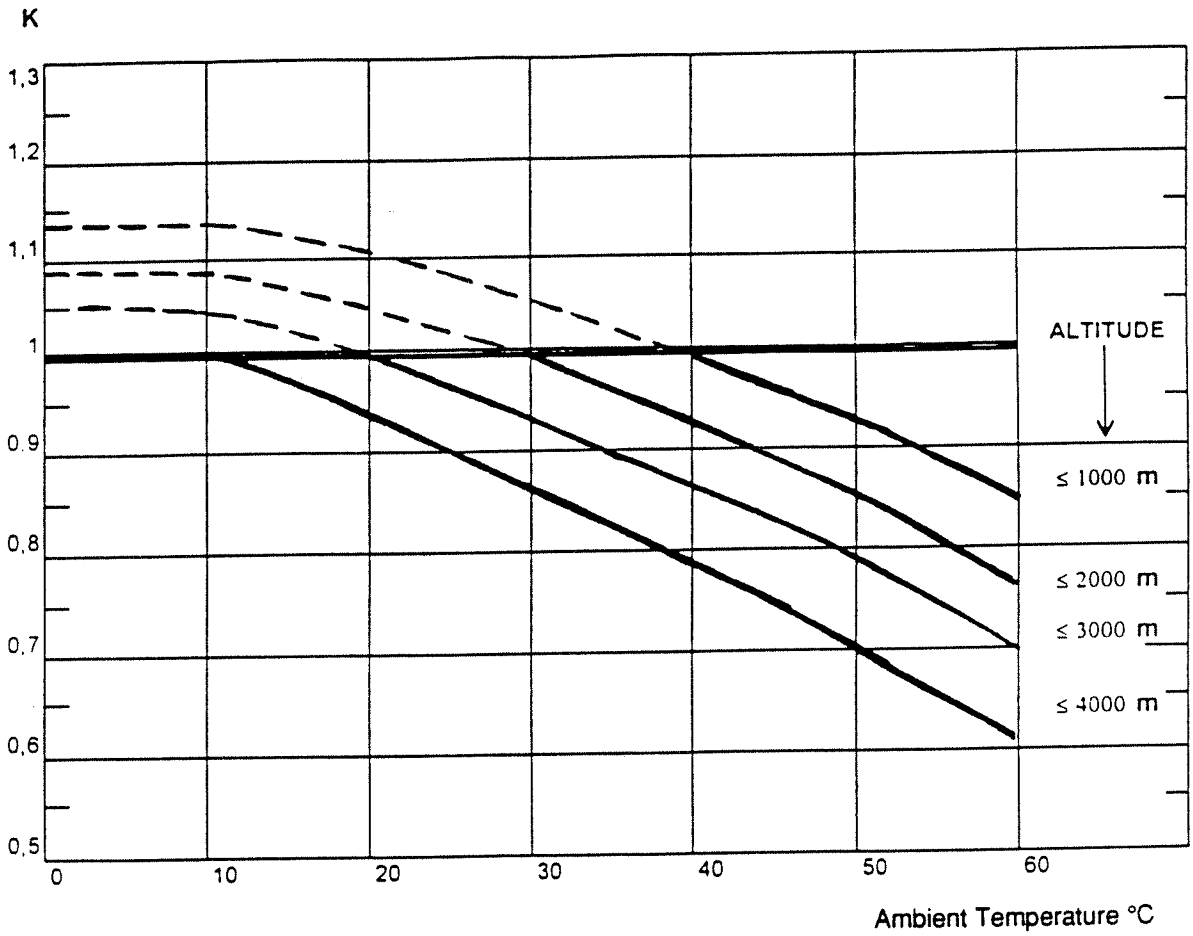

Diagram 5.8.1.5 = Correction as function of ambiant temperature and altitude

Note 1 : The K>1 coefficient values are to be defined between the motor manufacturer and the hoisting appliances manufacturer.

Note 2 : The ambient temperature shall be indicated above an altitude of 1000 m

5.8.1.6 Cyclic duration factor and number of working cycles per hour

The cyclic duration factor is given by the following formula :

$$ED = \frac{\text{Operating time}}{\text{Operating time} + \text{idle time}} \times 100\ (\%)$$

The operating time and the number of operations per hour of the motors as well as the number of working cycles of the crane, are an important base for the thermal definition of the motors and which should be agreed between the user and the manufacturer of the crane. In case it is not possible to give these indications in a precise manner, it should be referred to tables T 5.8.2.2 a and T 5.8.3.2 a.

5.8.2 MOTORS FOR VERTICAL MOTIONS

5.8.2.1 Determination of required torque

For a hoisting motor, the required power to raise the maximum nominal load (P_{Nmax}) is defined in kW in taking account of the configuration of the transmission and of the reeving according to the following formula :

$$P_{Nmax} = \frac{L.V_L}{\eta} 10^{-3}$$

Where :

L = maximum nominal permissible lifting force in N

V_L = lifting speed in m/s

η = efficiency of machinery

It gives the required torque to raise the maximum nominal load :

$$P_{Nmax} = \frac{P_{Nmax} \cdot 9\,550}{n}$$

n = rotating speed of the motor in mn^{-1}

In order to be able to develop the necessary torque for acceleration, for lifting the test load or for compensating for variations in the mains voltage and frequency, the torque developed by the motor must satisfy the following minimum condition :

- For squirrel cage motors with direct starting :

$$\frac{M_{min}}{M_{Nmax}} \geq 1{,}6$$

Where M_{min} is the minimum torque of the motor during starting.

- For slip ring motors :

$$\frac{M_{max}}{M_{Nmax}} \geq 1{,}9$$

M_{max} being the maximum torque of the motor.

For all types of motors which are fed by voltages and /or variable frequencies :

$$\frac{M_{max}}{M_{Nmax}} \geq 1{,}4$$

The mechanical braking torque at the motor shaft M_F should at least be equal to :

Static : $M_F \geq 2\ M_{Nmax} \cdot \eta^2$

Dynamic : $M_F \geq 1{,}5\ M_{Nmax} \cdot \eta^2$

Definition of the braking torque :

- Static : is the required minimum torque to prevent the SWL rotating the machinery.

- Dynamic : is the braking torque produced bye the brake during the whole duration of a braking cycle.

In the event of an electrical braking, it shall be capable to slow down the load in complete safety.

5.8.2.2 Cyclic duration factor and number of cycles per hour

In the case where no precise indications are given, the values mentioned in Table T 5.8.2.2.a can be chosen.

Table T. 5.8.2.2a

Indications for the number of cycles per hour and the cyclic duration factor for the vertical motions

Type of appliance				Type of mechanism FM %		
Ref.	Designation	Precisions conc. the type of utilisation 1)	Number of cycles per hour	Lifting	Derricking hinged boom	Derricking boom
1	Appliances with manual drive					
2	Jib cranes for assembling		2 - 25	25 - 40		25
3	Assembling and dismantling cranes for power stations machine shops...		2 - 15	15 - 40		
4	Stocking and reclaiming transporters	Hook	20 - 60	40	S2 15-30 min 2)	
5	Stocking and reclaiming transporters	Grab or magnet	25 - 80	60 - 100	S2 15-30 min 2)	
6	Workshop cranes		10 - 50	25 - 40		
7	Overhead travelling cranes, Pig breaking cranes Scrap charging cranes	Grab or magnet	40 - 120	40 - 100 60		
8	Ladle cranes		3 - 10	40 - 60		
9	Soaking pit cranes		30 - 60	40 - 60		
10	Stripper cranes, open hearth furnace charging cranes		30 10	60 60		
11	Forge cranes		6	40		
12.a	Unloading bridge cranes, Bridge cranes for containers	Hook or spreader	20 - 60	40 - 60	S2 15-30 min 2)	
12.b	Other bridge cranes (with crab and/or rotating crane)	Hook	20 - 60	40 - 60	S2 15-30 min	
13	Unloading bridge cranes, Bridge cranes (with crab and/or rotating crane)	Grab or magnet	20 - 80	40 - 100 60	S2 15-30 min 2)	
14	Shipyard jib cranes, dismantling jib cranes	Hook	20 - 50	40		40
15	Wharf cranes (rotating on bridge crane...), floating cranes and shear legs	Hook	40 20	60 40		40 - 60
16	Wharf cranes (rotating on bridge crane...), floating cranes and shear legs	Grab or magnet	25 - 60	60 - 100		40 - 60
17	Floating cranes and shear legs for heavy lifts (usually >100 t)		2 - 10	2) S1 or S2 30 min		2) S2 15-30 min
18	Deck cranes	Hook	30 - 60	40		40
19	Deck cranes	Grab or magnet	30 - 80	60		60
20	Site tower cranes		20	40 - 60		25 - 40
21	Derrick cranes		10	2) S1 or S2 30 min		2) S1 or S2 30 min
22	Railway cranes, admitted for railway traffic		10	40		

1) This column comprises only some indicatory typical cases of utilisation
2) it is recommended for S1 and S2 to refer to the definition IEC 34-1

5.8.3 MOTORS FOR HORIZONTAL MOTIONS

In order to select travel motors correctly, all the necessary torque (or power) values must be considered, taking into account the starting time, the number of starting cyles per hour and the cyclic duration factor. The maximum transmissible torque of the travel motors is limited by the adhesion of the driven travel wheels ont their tracks.

5.8.3.1 Determining the torque necessary

The maximum torque necessary is determined from the loadings specified in booklet 2 without taking into account the coefficient δ m.

Case I for cranes not exposed to wind
Case II for cranes exposed to wind
Case IIIa for cranes exposed to exceptional loadings (for the determination of the brakes).

The travel motors must delivery the necessary torque for the acceleration and the maintaining of the speed.

- Speed maintaining torque

To determine the torque necessary for maintaining the speed, account has to be taken of the sum of forces (w) resisting to travel resulting from the deadweight, the load and operating conditions such as :
. deformation of the running surface,
. friction of the wheels on straight sections and in curves,
. wind force,
. gradients in the track,
. necessary traction of power supply cable.

- Acceleration torque (running up to speed)

The acceleration torque shall take into account the sum of the accelaration forces of the mass of useful load and of the other masses put into motion.

For the acceleration values, see Table T 2.2.3.1.1 (booklet 2).

The necessary torque can be calculated by the following formula (see diagram 5.8.1.3.1)

Case I

$$M_1 \ldots M_n = \frac{(a\,[m+m_L]+w_0)\ v.60}{2\pi.n.\eta}$$

Case II

The largest of the values from the results of the following formula shall be taken into account :

$$M_1 \dots M_n = \frac{(a[m+m_L]+w_8)\ v.60}{2\pi.n.\eta}$$

and

$$M_1 \dots M_n = \frac{w_{25}\ .\ v.60}{2\pi.n.\eta}$$

where :

a : acceleration in m/s^2 (at constant speed $a = 0$)

m_L : mass of useful load in kg

w_0, w_8, w_{25} : total travel resistance in N (in certain cases of utilisation, w can become negative)

w_0 at zero wind

w_8 at a wind of 80 N/m^2

w_{25} at a wind of 250 N/m^2

v : travel speed in m/s

n : rotation speed of motors in mn^{-1}

η : overall efficiency of mechanism

m : equivalent mass in kg of all parts put into motion, excluding the load, which is supposed to be concentrated at the suspension point of the load.

$$m = m_0 + m_{rot} \cdot \eta$$

m_0 : mass in kg of the whole of the elements, excluding the load, undergoing the same horizontal motion as the suspension point of the load.

m_{rot} : equivalent mass in kg of the rotating parts referred to linear motion.

The inertia of the rotating masses, referred to linear motion is evaluated, using the the formula :

$$m_{rot} = \frac{1}{91{,}2} . \Sigma \left(J . \frac{n\chi^2}{v^2}\right)$$

where :

$n\chi$: speed of rotating masses mn-1

J : moment of inertia of all rotating masses in kgm^2

For determining the maximum torque of the motor, the highest value of the calculated torque shall be taken into account.

For slip ring motors used for the horizontal motions, the starting resistances shall be so defined that the minimum torque delivered by the motor is never less than 1,2 times the torque required to maintain the travel speed.

5.8.3.2 Cyclic duration factor and number of cycles per hour

In the case where no precise indications are given, the values mentioned in Table T 5.8.3.2.a. can be chosen.

5.8.3.3 Rotation

The calculation is carried out in an analogous fashion to clause 5.8.3.1, angular speeds being substituted for the linear speeds.

5.8.3.4 Span variation

If the span variation in the case of luffing jibs, leads to an elevation or to a lowering of the centre of gravity of the masses put into motion, the calculation can be carried out in an analogous fashion to clause 5.8.3 in inserting into the factor (w) the forces required to the vertical displacement of the centre of gravity.

Table T. 5.8.3.2a

Indications for the number of cycles per hour and the cyclic duration factor for the horizontal motions

Type of appliance				Type of mechanism FM %		
Ref.	Designation	Precisions conc. the type of utilisation 1)	Number of cycles per hour	Rotation	Crab	Travel
1	Appliances with manual drive					
2	Jib cranes for assembling		2 - 25	25	25 - 40	25 - 40
3	Assembling and dismantling cranes for power stations machine shops...		2 - 15		25	25
4	Stocking and reclaiming transporters	Hook	20 - 60	15 - 40	40 - 60	25 - 40
5	Stocking and reclaiming transporters	Grab or magnet	25 - 60	40	60	15 - 40
6	Workshop cranes		10 - 50		25 - 40	25 -40
7	Overhead travelling cranes, Pig breaking cranes Scrap charging cranes	Grab or magnet	40 - 120		40 - 60	60 - 100
8	Ladle cranes		3 - 10		40 - 60	40 - 60
9	Soaking pit cranes		30 - 60	40	40 - 60	40 - 60
10	Stripper cranes, open hearth furnace charging cranes		30 10		40 40	60 40
11	Forge cranes		6	100	25	25
12.a	Unloading bridge cranes, Bridge cranes for containers	Hook or spreader	20 - 60	15 - 40	40 - 60	15 - 40
12.b	Other bridge cranes (with crab and/or rotating crane)	Hook	20 - 60	25 - 40	40 - 60	25 - 40
13	Unloading bridge cranes, Bridge cranes (with crab and/or rotating crane)	Grab or magnet	20 - 80	40	40 - 100	15 - 60
14	Shipyard jib cranes, dismantling jib cranes	Hook	20 - 50	25	40	25 - 40
15	Wharf cranes (rotating on bridge crane...), floating cranes and shear legs	Hook	40 20	25 - 40	40	15 - 25
16	Wharf cranes (rotating on bridge crane...), floating cranes and shear legs	Grab or magnet	25 - 60	40 - 60		25 -40
17	Floating cranes and shear legs for heavy lifts (usually >100 t)		2 - 10	15 - 40		
18	Deck cranes	Hook	30 - 60	40		
19	Deck cranes	Grab or magnet	30 - 80	60		
20	Site tower cranes		20	40 - 60	25	15 - 40
21	Derrick cranes		10	25		
22	Railway cranes, admitted for railway traffic		10	25		

1) This column comprises only some indicatory typical cases of utilisation

5.9. **LOAD LIFTING MEANS**

5.9.1. CURRENT SUPPLY

In view of the arduous duty to which current supply systems are subjected, the electrical equipment must be selected and installed with special care.

- Supply cables should be able to be wound on cable winders and their mechanical strength, resistance to external influences and heat-resistance, must be suitable for the service conditions.
- Cable fixing means should be so selected that all strain on the connections or damage to the cables is avoided.
- Cables should be installed and guided in such a way as to exclude the possiblity of damage in normal service.

5.9.2. LIFTING MAGNETS

5.9.2.1. **WINDINGS**

The insulation class of the windings should be selected according to the power loss, the ambient temperature and, if necessary, the heating caused by the goods handled.

5.9.2.2. **DUTY**

Lifting magnets are normally designed for a cyclic duration factor of 50 %. Other cyclic duration factors should be agreed between the manufacturer and user.

5.9.2.3. **PERFORMANCE**

The lifting capacity of a lifting magnet should be specified for a precise load at rated voltage and operating temperature of the magnet coil.

5.9.2.4. **SAFETY FACTOR**

The tear-off force should be at least twice the lifting capacity.

5.9.2.5. **STAND-BY SUPPLY**

If there is a stand-by power supply from batteries, the holding time should be at least 20 minutes. In this case, an automatic charging unit and a charge level indicator should be provided. Use of the stand-by supply should be indicated visually and audibly for general warning. If the battery voltage level is not adequate, a device preventing the installation from being used should come into effect.

5.9.3. GRABS

5.9.3.1. DRIVES

The drive motor (electro-hydraulic or electro-mechanical drive) should be designed for S3, S4 or S6 duty depending on type and application.

5.9.3.2. DEGREE OF PROTECTION

In normal service, the motors and electrical equipment must comply with IP 55 at least. For underwater operation the degree of protection must be IP 57 at least. Due to the special service conditions of this equipment, jolts and vibrations must be given particular attention.

5.9.4. LOAD TURNING EQUIPMENT

5.9.4.1. DESIGN

Load turning equipment should be so designed that loads can be accelerated and braked without the ropes twisting. The arrangement of the lifting ropes, the load, the lifting height, the centre of gravity and the moment of inertia of the load and loading beam if applicable should be taken into account in the design of the equipment.

The installation of guides such as telescoping or articulated systems may be used in order to prevent the twisting of ropes.

5.9.4.2. POWER SUPPLY TO TURNING PARTS

For supplying electrical power to turning parts, the current supply system should be designed in accordance with the turning range.

5.9.4.3. DEGREE OF PROTECTION

If the turning motor is mounted on the supporting structure of the hoisting appliance, it must comply with the degree of protection of the other motors on the structure at least.

If the turning motor is mounted on the load lifting means, it must comply with IP 44 at least for indoor operation and IP 55 for outdoor operation.

5.10 CHECKS AND MAINTENANCE

5.10.1. MAINTENANCE

The electrical equipment of a hoisting appliance should be maintained in good condition. Maintenance should be based on the duty class and load spectrum of the hoisting appliance and carried out in accordance with the instructions of the supplier or manufacturer.

5.10.2. CHECKS

A distinction is made between regular checks and checks made before the appliance is commissioned.

Regular checks are subdivided into simple checks and comprehensive checks.

5.10.2.1. REGULAR CHECKS

5.10.2.1.1. Simple checks

The safety devices which can be checked from the control position are to be checked regularly, in principale before the start of each workday, for their proper electric functioning.

In particular, the following, at least, must be checked :

- emergency limit switches,
- brake functions,
- emergency cut-out.

5.10.2.1.2. Comprehensive checks

At least once a year, the electrical equipment of a hoisting appliance should be given a comprehensive check.

Besides the above simple checks, the following should be checked thoroughly :

- the settings and conditions of the electrical safety devices,
- integrity of protective earth systems,
- integrity of equipotential circuits,
- insulation of all the electrical equipment,
- tightness of all connections,
- predetermined resistance values, if any,
- physical condition of cables and cable inlets,
- physical condition of safety devices,
- presence and condition of devices protecting against direct contact,
- the technical performance of replaced parts is compatible with the proper functioning of the hoisting appliance.

5.10.2.2. CHECKS BEFORE COMMISSIONING

In addition to the comprehensive checks, the checks before commissioning include, at least :

- checking that all the hoisting appliance's electrical equipment is in conformity with national regulations and standards,

- checking that the electrical equipment agrees with the circuit diagrams,

- checking the switching sequence of the safety and control circuits,

- checking the proper functioning and correct selection of the electrical components in accordance with the expected operating conditions for the hoisting appliance,

- checking that the performance data of motors is in conformity with their use.

- checking that the control system does not permit any uncontrolled excess speeds in normal operation,

- checking the correct settings for all the electrical equipment and its proper functioning.

5.11. AUXILIARY ELECTRICAL EQUIPMENT

5.11.1. LIGHTING

5.11.1.1. CABIN

- A fixed non-dazzling service lighting will be provided, so arranged that only the necessary illumination for the lighting of the control equipment is provided.

- When the general area lighting equipment is not sufficient to permit access and exit out of the cabin in safety, supplementary portable lighting will be provided ; this equipment must be able to work, even if the principal electrical circuits of the crane are isolated.

5.11.1.2. WORKING AREA LIGHTING

- When the working area lighting is provided by the appliance, projectors will be suitably placed on the crane, so that a minimum illumination of 30 lux at ground level is gurаranteed.

- This lighting circuit will be independent of the principal circuits of the hoisting appliance.

- Precautions must be taken to avoid voltage drops produced by starting the motors cutting out the gas discharge lamps.

5.11.1.3. ACCESS AND MACHINERY CABINET LIGHTING

When the general area lighting does not permit sufficient illumination, supplementary lighting independent of the principal circuits of the hoisting appliance will be provided. The minimum illumination will be 30 lux.

5.11.1.4. EMERGENCY LIGHTING

When the lighting of the area does not permit exit out of the appliance in safety, a portable lamp, equipped with batteries will be provided. A battery charger must be provided in the cabin.

5.11.2. HEATING AND AIR-CONDITIONING

5.11.2.1. **MACHINERY CABINETS**

- Natural or forced ventilation will be provided to disperse thermal power generated by the machinery and its equipment.

- Where electronic equipment is used and working conditions do not guarantee an ambient temperature for proper functioning of the electronic equipment, an air conditioning unit will be provided.

5.11.2.2. **CABIN**

If necessary heating appliances will be provided in the cabin.

This apparatus of black heat/non-radiant type shall be securely fixed. It must be provided with a thermostat and must have such a power to assure a minimum temperature of 15° C, taking into account the environment in which the equipment is installed. This apparatus must be fed independently of the principal circuits of the hoisting appliance.
If required by the environment an air conditioning unit will be installed in the cabin to maintain a maximum acceptable temperature. This apparatus must be fed by a circuit independent of the principal circuits of the hoisting appliance.

5.11.3. AUXILIARY CIRCUIT

If there is no possibility of supply in the proximity, auxiliary circuits must be provided for maintenance purposes, as follows :

- A circuit for portable lighting with a minimum power of 200 W, if the ambient lighting is not sufficient to carry out maintenance.

- A circuit for portable tools with a minimum power of 2 kW low voltage of 100 V or 220 V. This circuit must be protected by a differential circuit breaker of high sensitivity.

These circuits will be independent of the principal circuits of the hoisting appliance and the voltage must be indicated near the socket outlet. All measures will be taken to avoid confusion between very-low-voltage and low-voltage.