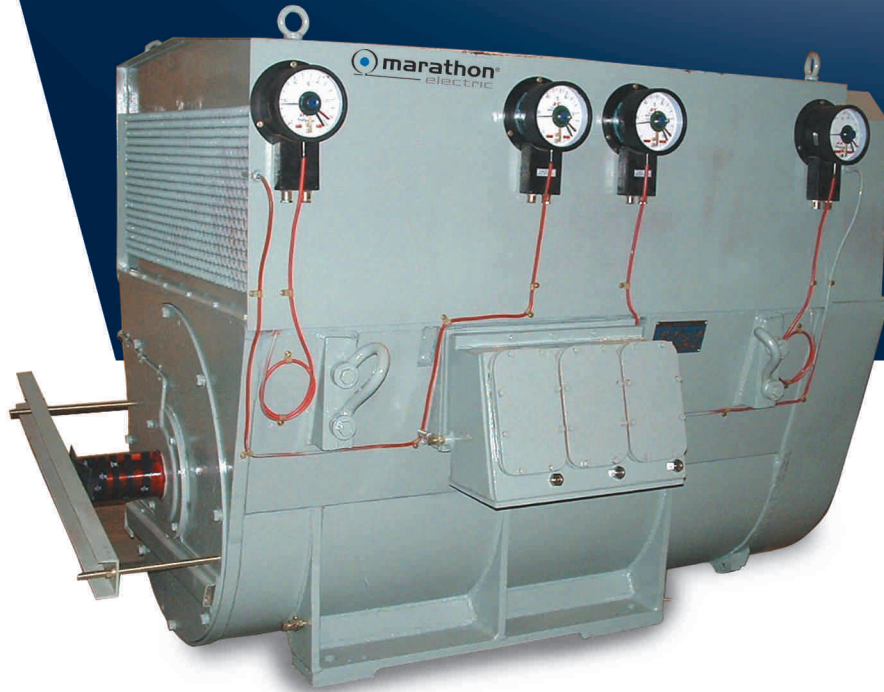




marathonTM
Motors



Impak
CACA

High Voltage AC Induction Motors

A Regal Brand

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Impak high voltage range

Frames 355, 400 & 450

The Impak range has been designed to provide the maximum variety of cooling forms and enclosures, whilst still utilising standardised electrical components.

Two stator frames have been developed for each frame size : a horizontal foot mounting frame, mounting designation IM 1001, and a vertical flange/skirt mounting frame, mounting designations IM3011/3611.

The horizontal foot mounting frame has an open top with

machined faces to accept the cover or heat exchanger. The vertical flange/skirt' mounting frame has two open sides with similarly machined faces.

The specified range of cooling forms and enclosures is available on each mounting arrangement.

The first part of this publication details the mechanical features while the second part deals with electrical information.

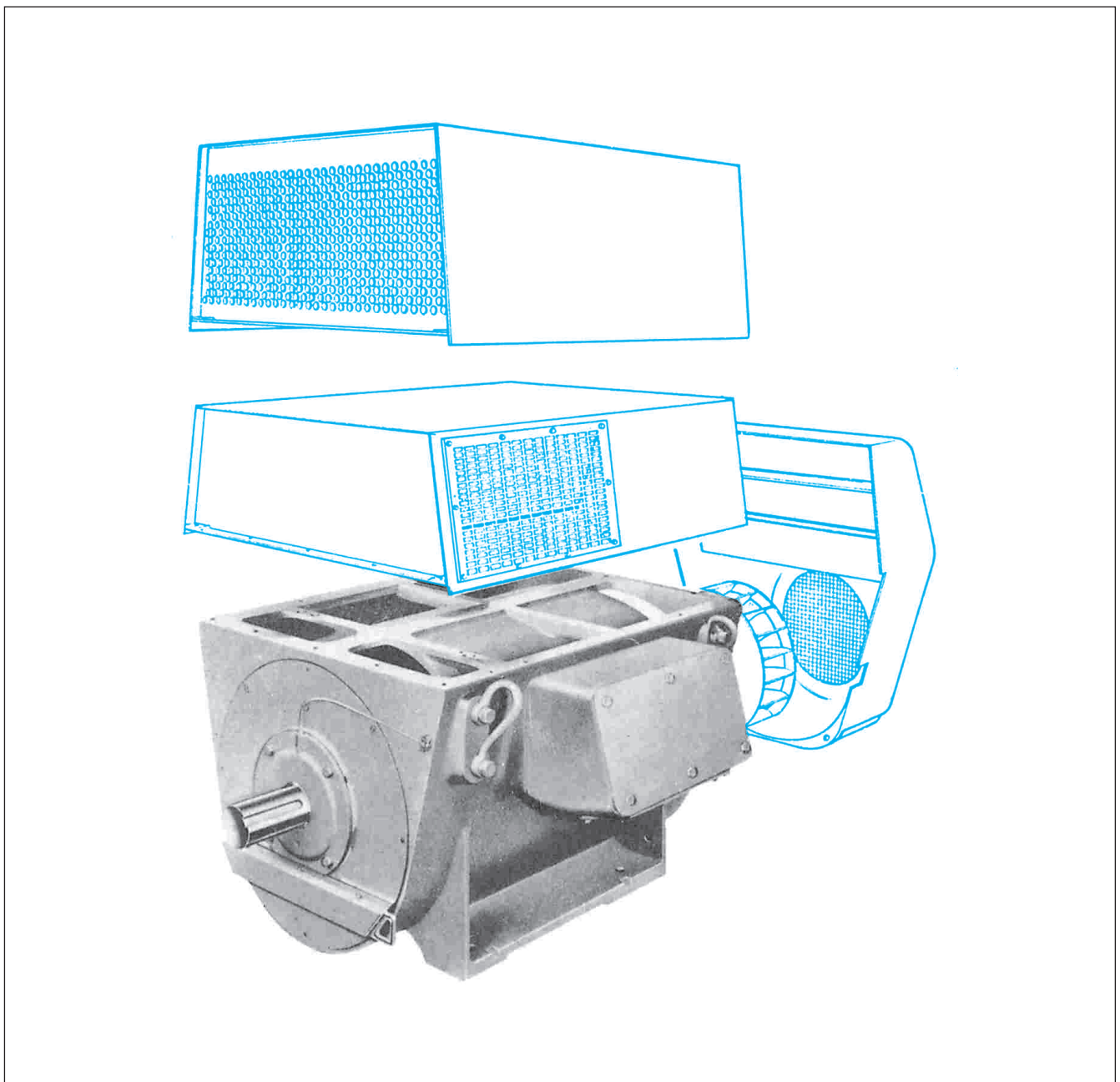


Fig. 1. Horizontal Mounting HT Motor

Standards and specifications

Performance

Standard Impak induction motors comply with requirements of B-1 and with BS 4999-Part 4, 30, 31, 42, 50, 51, 60, 61, 69 and 72 and Indian Standard IS 325, 8223, 4829 and other relevant Indian Standard Specifications.

Motors for Variable Speed Drive (VSD) applications are also available.

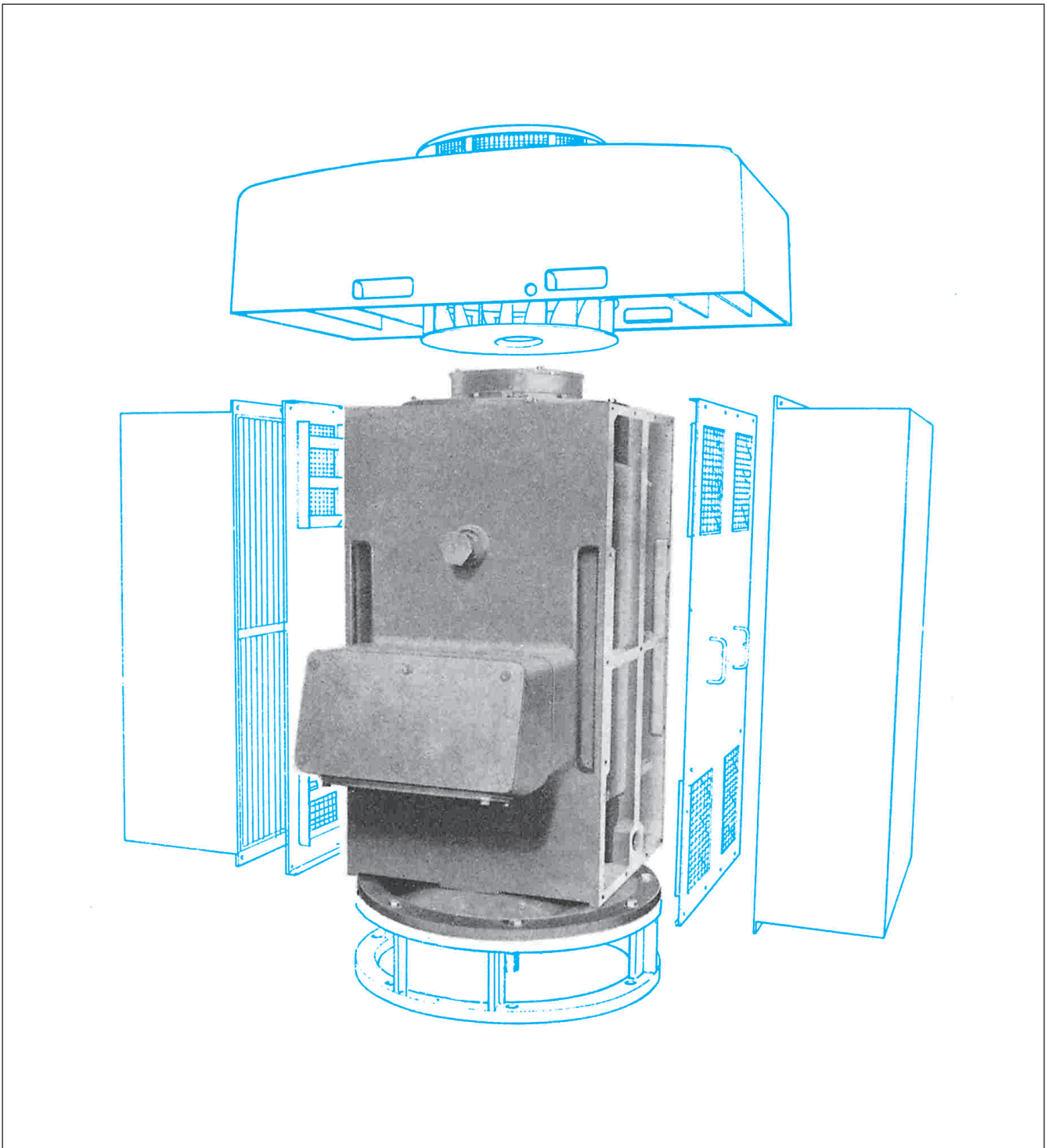


Fig. 2. Vertical Mounting HT Motor.

Mechanical data

Standards & specifications of mechanical features :

Degrees of protection by enclosure

Degrees of protection available conform to requirements of IEC 34-5, BS 4999-Part 20, 1972 and Indian Standard IS 4691 and other relevant Indian Standard Specifications.

The standard degrees of protection are IP 54 & IP 55. However, if required, we can offer machines with IP 23 degree of protection.

The Impak range has been designed to provide the maximum variety of cooling forms and enclosures, whilst still utilizing standardised electrical components.

Cooling Forms

Cooling arrangements are in accordance with IEC-34-6 and BS 4999 Part 21.

The standard cooling form for machines with degrees of protection IP 20 to IP 23 is enclosed ventilated IC 01. This

is achieved by use of a shaft mounted fan with free air inlet and outlet.

For a machine with degree of protection IP-44 or IP 55 the usual cooling arrangement is totally enclosed fan ventilated IC 0161, utilizing an independent machine mounted heat exchanger and shaft mounted fans. Motors with force cooling system are also available.

Mounting

Mounting designations are in line with IEC-34-7 Code 11 and BS 4999 Part 22 Code 11.

The standard arrangements available are horizontal foot mounting IM 1001 and vertical flange mounting IM 3001.

The horizontal foot mounting frame has an open top and vertical machine has two open sides. All such faces are machined to accept heat exchanger or cover.

Dimensions

Shaft and fixing dimensions are to BS 3979 and BS 4999 Part 10 or IS 8223-1976. The recommendation of IEC-72 and IEC-72A can also be met.

Table 1. The degrees of protection

The codings offer protection against IP20	Contact with live or moving parts by objects with diameters of 12mm and above	-	-
IP22	-do-	Ingress of foreign bodies with diameters of 12mm and above	Harmful effects of water falling at any angle up to 15 from the vertical
IP23	-do-	-do-	Harmful effects of water falling as a spray at an angle equal to or smaller than, 60 with respect to the vertical
IP44	Contact with live or moving parts by objects of 1mm thickness	Ingress of foreign bodies with diameters of 1mm and above	Harmful effects of water splashed against the motor from any direction
IP54	Contact with live or moving parts (complete protection)	Ingress of harmful deposits of dust to an amount inconsistent with correct operation	Harmful effects of water splashed against the motor from any direction
IP55	-do-	-do-	Harmful effects of water projected by a nozzle against the motor from any direction

Table 2. Cooling forms

One (primary) cooling circuit	IC01	Open	Shaft-mounted fan only, Free inlet and outlet
Two (primary/secondary) Cooling circuits	IC0161	Closed	Independent machine-mounted heat exchanger Shaft-mounted fans.

General construction

Stator construction

Stator Frame

Horizontal Mounting Machines

The stator frames are of cast iron / fabricated steel construction with an open flat top and terminal outlet on each side. The side walls are recessed to accommodate the socket head screws that secure the various alternative covers. Internal ribbing provides high structural strength. Registers to accept and spigotted bearing brackets are machined into the frame. Feet and lifting eyebolt bosses are cast integral with the frame.

Vertical Mounting Machines

Stator frames for vertically mounted machines are similar in design to those for horizontally mounted machines but certain frames are offered with a fabricated steel construction.

Stator frames for both horizontal and vertical mounting machines have a smooth 'wipe-down' exterior with clean modern lines.

Lamination

HT motors are generally manufactured by using cold rolled non-grain oriented low loss steel sheet. This results in a better and efficient machine of low weight and compact design.

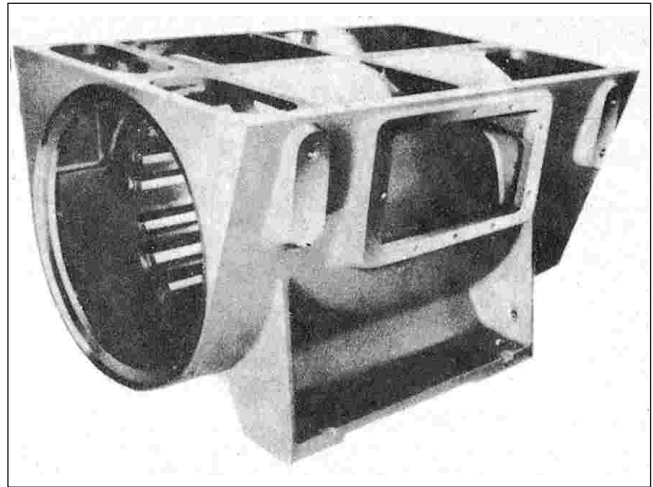


Fig. 3. The stator frame of a horizontal mounting Impak motor showing the strong internal structure.

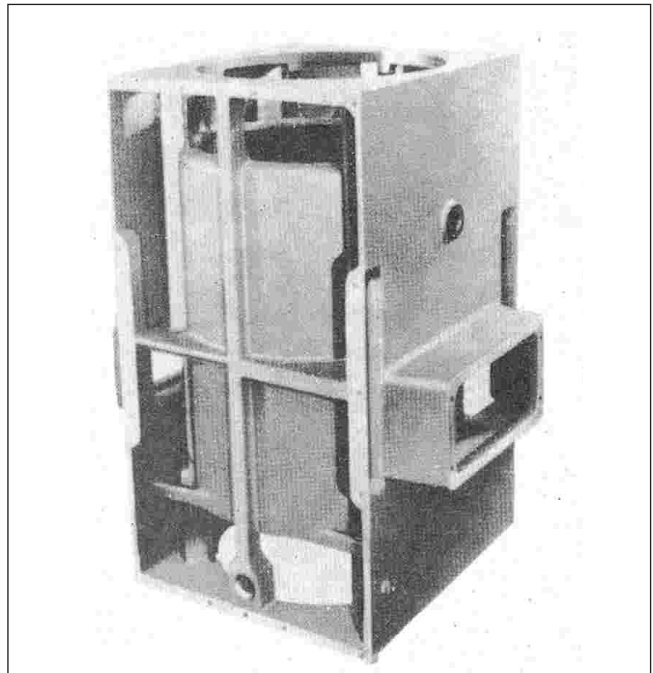


Fig. 4. The stator frame of a vertical mounting motor showing the similarity of internal construction to the horizontal mounting version.

Stator core

The machines have laminations built into them located by a key, compressed between steel endplates and locked in position by a steel key ring.

Bearing Brackets (End shields)

Bearing brackets on most machines are produced from the same grade of cast iron as employed for the stator frame. Some vertical machines designed to accommodate high

thrust forces have fabricated steel brackets.

All bearing brackets have a machined spigot to locate into the stator frame and ensure concentricity. Brackets are secured by steel bolts.

Horizontally-mounted machines with grease-lubricated rolling bearings have expelled grease trays manufactured from extruded aluminium or if specified, steel, mounted on the bearing brackets.

Bearings

Horizontal foot mounting machine

Standard rolling bearings, grease-lubricated

This is the standard arrangement for all but 2-pole 400 and 450 frames operating on a 50/60 Hz supply.

ISO metric dimensioned rolling bearings are mounted directly into bores in the bearing endbrackets. Inner bearing races are locked onto the shaft by shaftnuts and grub screws.

Inner bearing caps of cast iron position the outer races and are also used during dismantling as bearing extractors for the full bearing.

Outer caps of cast iron prevent axial movement of the bearing and contain a weather sealing arrangement as standard. Dust-protecting outer caps are available to special order.

Grease nipples are provided for lubricating the bearings with the motor either stationary or running.

A pressure relief system embodying a rotating grease valve is included as standard.

By the means of grease removal devices fitted to the endbrackets, surplus grease ejected from the bearings can be removed whilst the motor is either stationary or running. The expelled grease trays are manufactured from extruded aluminium or, if specified, steel.

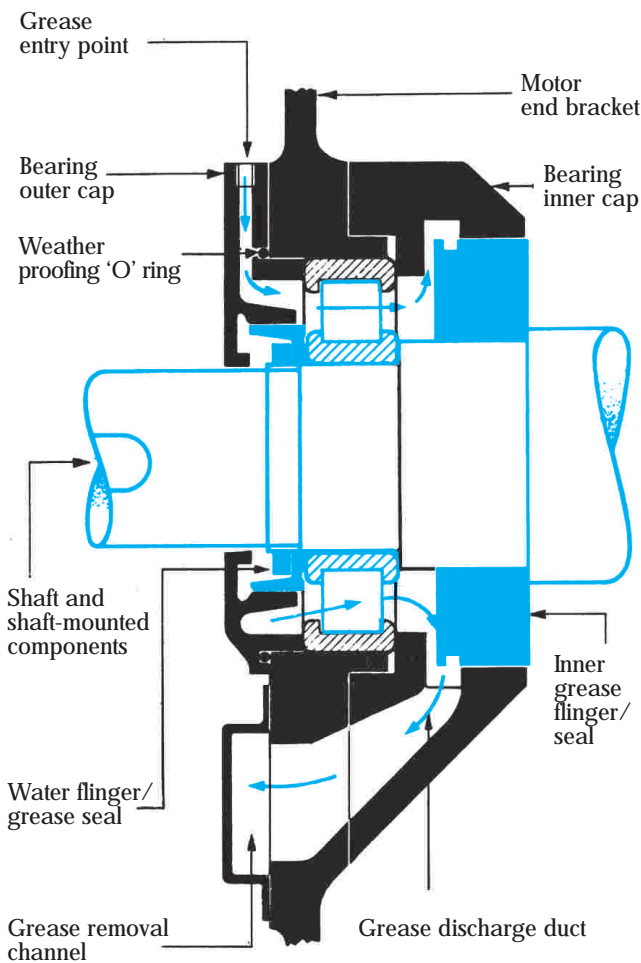


Fig. 5. The arrangement of the grease-lubricated rolling bearings. The grease enters the bearing from the outboard side and surplus grease is ejected by the flinger.

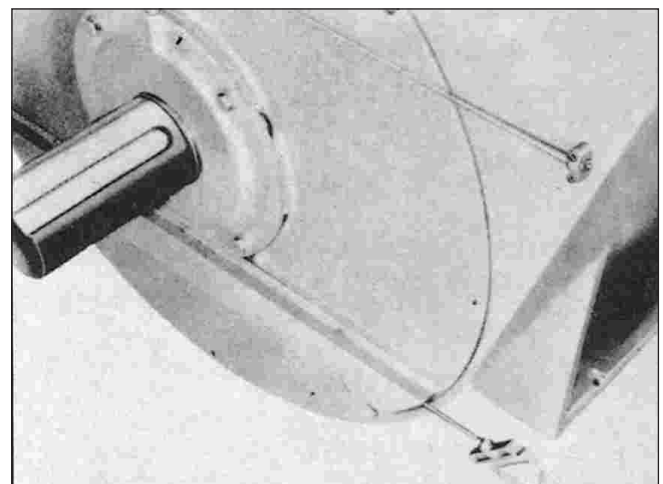


Fig. 6. View of an Impak showing the lubrication point, expelled grease tray (in the open position) and dust-protecting outer bearing cap.

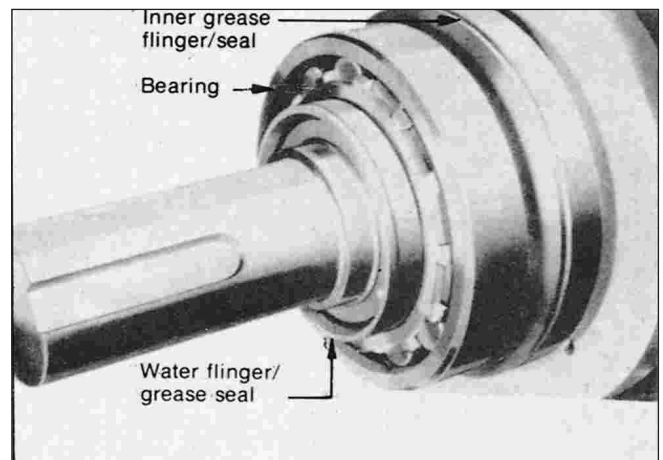


Fig. 7. Shaft-mounted components. The inner grease flinger/seal is an interference fit on the shaft. The outer water flinger/grease seal is secured to the shaft by a nut.

Vertical flange/vertical skirt mounting machines

Top bearing

The top bearing arrangement supports the weight of the motor and any external axial thrust within the bearing capability.

The standard arrangements are of either the four point contact ball or taper roller types.

The choice depends upon the lubrication requirements corresponding to the motor speed and the amount of axial thrust that has to be supported. With both bearing arrangements axial thrust can be accommodated in either or both directions.

Four point contact ball bearing – grease-lubricated

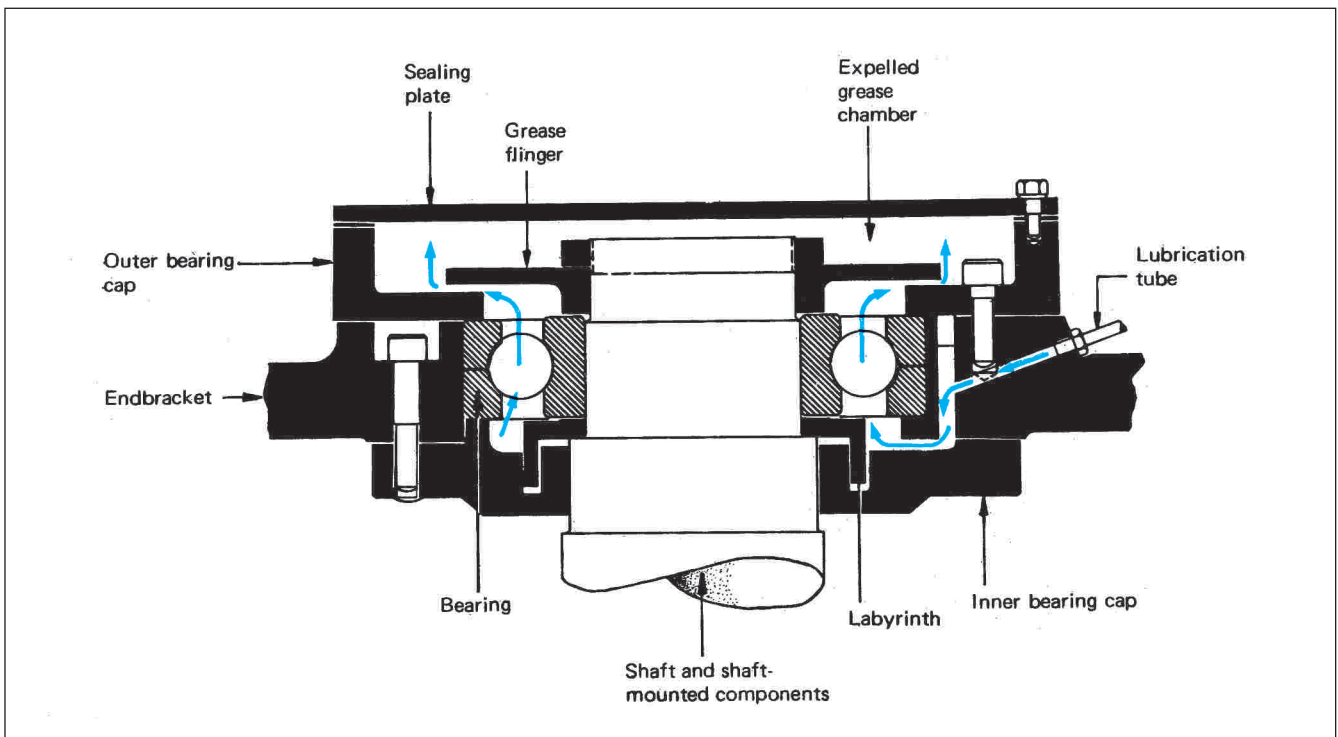


Fig. 8. A typical four point contact ball bearing arrangement on motor.

This is the standard arrangement for 355 and 400, 4 to 12 pole, and 450, 6 to 12 pole, motors operating on a 50 Hz supply and all 8 to 12 pole motors operating on a 60 Hz supply.

ISO metric dimensioned rolling bearings are mounted directly into bores in the cast iron or steel endbrackets. Inner bearing caps are of cast iron. Inner bearing races are locked onto the shaft by shaftnuts and grub screws.

The bearing enclosure is weather-protected and a pressure relief system embodying a rotating grease valve is included as standard. Dust-protecting outer caps are available to special order. Grease nipples are provided for lubricating the bearings with the motor stationary or rotating. A shaft-mounted grease flinger transfers surplus grease to a chamber which should be cleaned out periodically.

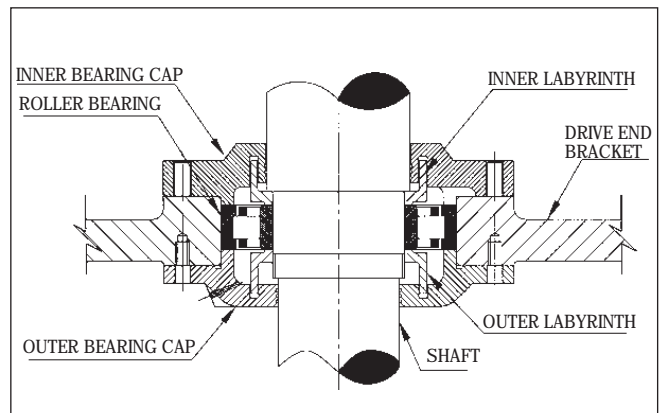


Fig. 9. Typical drive end bearing arrangement of vertical motor.

Bottom bearing

Roller bearings – grease – lubricated

This is the standard arrangement for 355, 2 to 12 pole, and 355, 400 & 450, 4 to 12 pole motors, operating on either a 50 or 60 Hz supply.

ISO metric dimensioned bearings are mounted directly into bores in the cast iron endbrackets.

Inner bearing caps of cast iron position the outer races. Outer caps of cast iron prevent axial movement of the bearing and contain a weather sealing arrangement as standard. Dust-protecting outer caps are available to special order.

Grease nipples are provided for lubricating the bearings with the motor either stationary or running. A pressure relief system embodying a rotating grease valve is included as standard.

Expelled grease is stored in a chamber which should be cleaned out periodically.

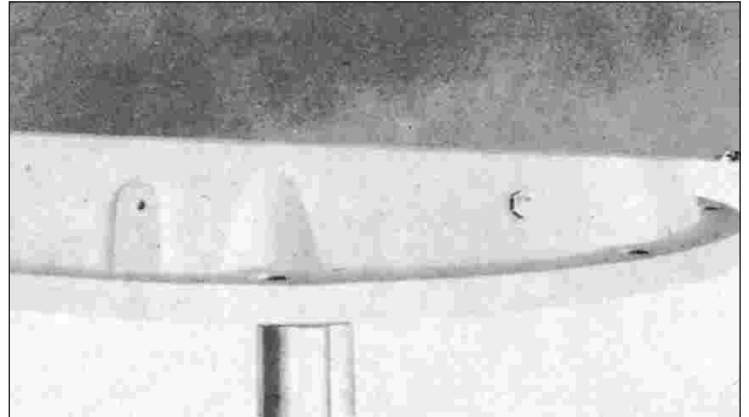


Fig. 10 Close-up of the lubrication point for grease-lubricated roller bearings on a vertical flange mounting motor.

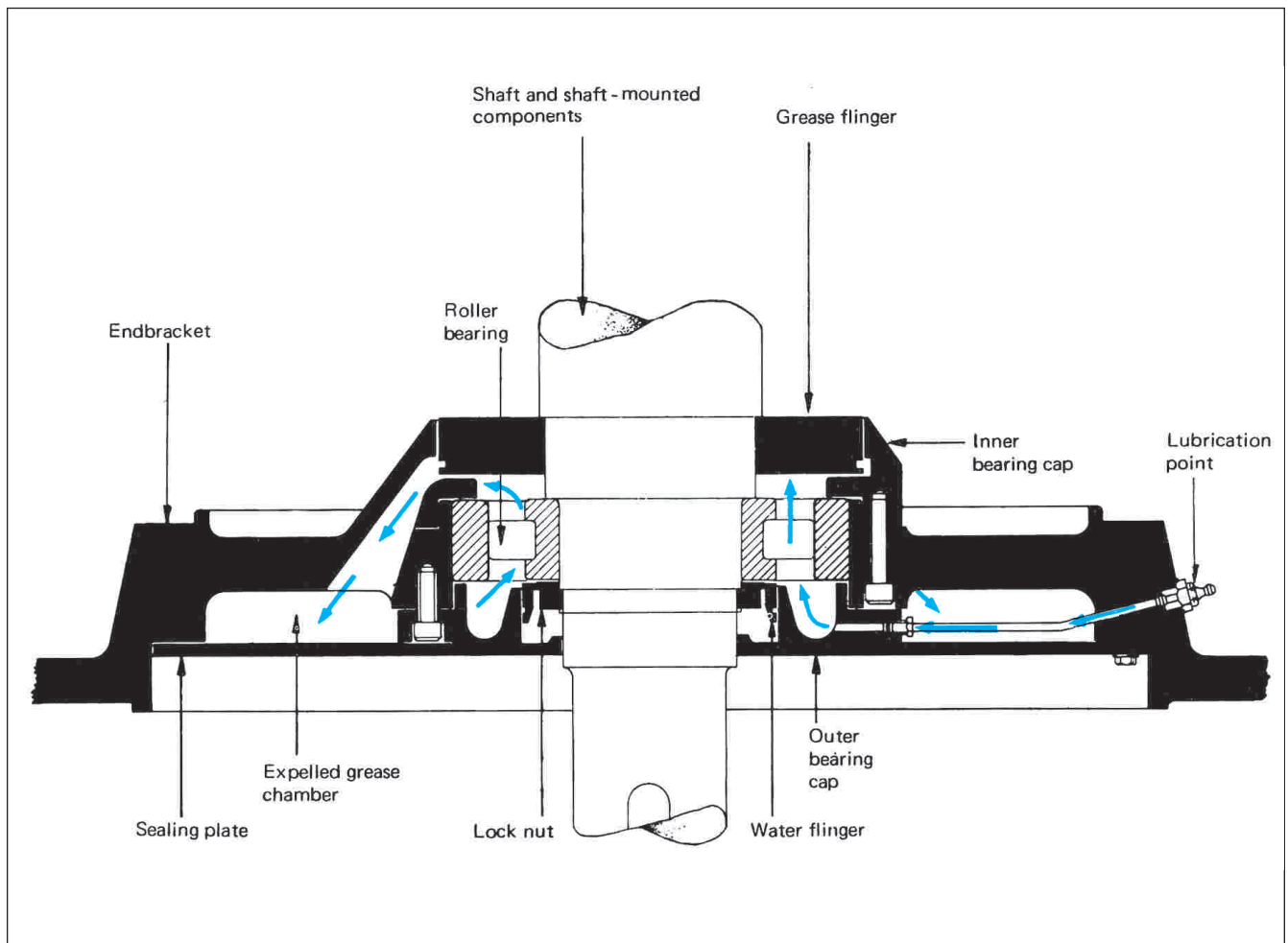


Fig. 11. A typical grease-lubricated roller bearing arrangement.

Bearing Lubrication

The tables given below show the bearing sizes lubricating machines. However in special applications different interval and quantity of grease required for standard bearings/bearing arrangements can also be provided.

TABLE 3

Bearing size, lubricating interval and grease capacity of horizontal foot mounted IM 1001, CACA, IP 44, 54 & SPDP, IP 22, 23 MOTOR (up to 6.6 kV)

Frame	Pole	Bearing Details		Quantity of lubricants		Lubricating Interval (Running) (hours)
		Driving end (Roller bearing)	Non-driving end (Ball bearing)	Driving end cm	Non-driving end cm	
D355	4 6-12	N 321	6321	2100	2100	4000 8000
D-400	4 6-12	N324	6324	2500	2500	4000 8000
D450	4 6-12	N324	6324	2500	2500	4000 8000

1. Lithium base grease to be used e.g. M.P. 3 of Bharat Petroleum, Servogem 3 of I.O.C. or equivalent.
2. Over greasing is not recommended.

TABLE 4

Bearing size, lubricating interval and grease capacity of vertical flange/skirt mounted IM 3011/IM 3811, IP 44, 54, 22, 23 (up to 6.6 kV) Motor

Frame	Pole	Bearing Details		Quantity of lubricants		Lubricating Interval (Running) (hours)
		Driving end (Roller bearing)	Non-driving end (Ball bearing)	Driving end cm	Non-driving end cm	
355	4 6-12	N 321	QJ 320	2100	2100	4000
		N 321	QJ 320	2100	2100	8000
400	4 6-12	N324	QJ 320	2500	2100	4000
		N 324	QJ 320	2500	2500	8000
450	6-12	N324	QJ 320	2500	2500	4000

1. Lithium base grease to be used e.g. M.P. 3 of Bharat Petroleum, Servogem 3 of I.O.C. or equivalent.
2. Over greasing is not recommended.

Rotor Core, Shaft and shaft-mounted

Rotor Core

The rotor core is built up of laminations on the shaft with a light interference fit and positioned by a key. The laminations are compressed between steel endplates and locked by a steel key ring or nut. The winding comprises copper strips brazed to endrings for squirrel cage rotor and TIG Welded with relevant bar using a 'C'-clip for slip ring rotor.

Shaft

Shafts are designed to eliminate the risk of fatigue or other failures. Standard material is carbon/manganese steel of suitable grade. We normally use forged bar as shaft material. Shaft extension lengths and diameters have been specified in respective dimensional drawings. However, different extension lengths can also be offered. The shaft end can be tapped with one or two holes for coupling/pulley withdrawal.

Key are single round-end parallel run out as standard.

Internal Fan

The internal fan is fabricated from sheet and added to a steel hub. The hub is a light shrink fit onto the shaft. A key secures the fan radially to cope with stresses imposed by torque pulsations from driven equipment and/or frequent reversals.

Although it is rarely necessary to remove the fan, this key ensures reassembly in the correct position for undisturbed balance.

All 2 pole machines are normally fitted with unidirectional fans. Radial bladed versions of these centrifugal fans are available to special order. Motors of other polarities are offered with bi-directional fans.

External Fan

Fans are of fabricated steel construction similar to internal fan described here. Fan is secured radially by a full key and a minimum clearance fit. Axial movement is prevented by a shaft nut locked by a grub screw. External fan can be supplied epoxy painted for use in corrosive atmosphere.

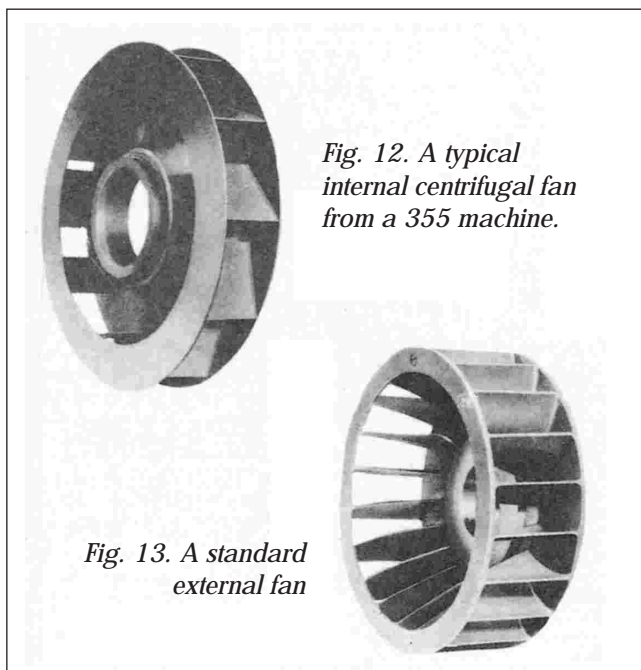


Fig. 12. A typical internal centrifugal fan from a 355 machine.

Fig. 13. A standard external fan

Covers and heat exchanger

In most cases the degree of protection and the cooling form are both established by the design and construction of the cover or heat exchanger.

Vertical machines incorporate two covers or heat exchangers the designs of which are basically similar to the single unit fitted to the horizontal foot mounting machines.

Covers and heat exchangers are of welded steel sheet construction with internal stiffening ribs and damping strips where necessary and are secured by flat, gasketed bolted joints to the frame. The gaskets are made from neoprene-bonded rubber fixed with plastic cement.

Cooling Form IC01

Inlet and outlet openings protected by screens. Internal louvres (single or double) are fitted inside covers on certain degrees of protection.

IC01 motors with IPW 24S degree of protection have covers producing weather protection as defined in NEMA II MGI : 1972.

The ventilating passages at both intake and discharge minimize the entrance of rain, snow, and airborne particles and also allow high velocity air and airborne particles blown into the machine by high winds to be discharged without entering the international ventilation passages.

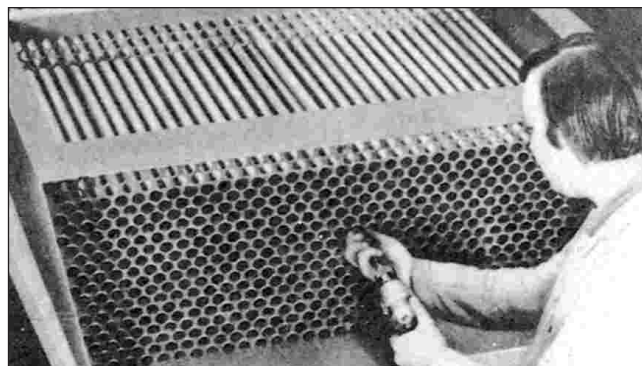


Fig. 14. Heat exchanger tubes being expanded into the steel tubeplate at the outlet. Tubes are locked at the centre and inlet by total immersion of the completed heat exchanger in isophthalate polyester varnish with subsequent heat curing.

Air paths are baffled to provide three 90 changes of direction and this, together with an area of low velocity in the intake path, minimises the possibility of moisture or dirt reaching electrical parts.

Cooling Form IC0161

The external fan cowl is manufactured from fabricated sheet steel.

On both cowls galvanized steel wire mesh guards the fan inlet against access of the standard test finger as illustrated in Fig. 1 of IEC Publication 34-5.

Cooling Forms IC 0161 & IC0 66

The heat exchanger tubes are housed in the 3mm thick mild steel cover. IC416 is also available on request.

Terminal arrangements

1. Two machine facings are provided on the stator frames of both horizontal and vertical mounting motors.

On the horizontal motors the standard position for the main terminal box is on the right hand side looking at the drive end of the motor.

2. On both mountings the terminal box can be arranged to give two directions of cable entry at 180 intervals. Adaptors are available to permit rotation of cable entry in 90 steps.

3. The standard terminal arrangement, for use on low fault capacity systems is a weather-proof steel terminal box with continuous flanges and neoprene-bonded gaskets to ensure dust-tight joints. The terminal bars are of epoxy moulded glass resistant material. High voltage terminal bars are provided with flash barriers between terminals. The leads from the stator winding to the terminal box are securely clamped to the stator frames.

The terminal box is equipped with an adaptor plate drilled and tapped to receive the incoming cables, alternatively a sealing chamber complete with armour clamps can be fitted. The choice depends upon the type and size of the supply cables that are to be used .

for use on high fault capacity installations. The design of the industrial phase segregated terminal box not only minimises the possibilities of a fault but also in the event of a fault occurring will limit its magnitude by ensuring that a line-to-line fault cannot develop. The phase segregated terminal box has been successfully tested on systems having fault capacities up to 250 MVA at 3.3 kV and 500 MVA at 6.6kV for a fault duration of 0.25 second. Fig 15 shows individual components of Phase segregated terminal box.

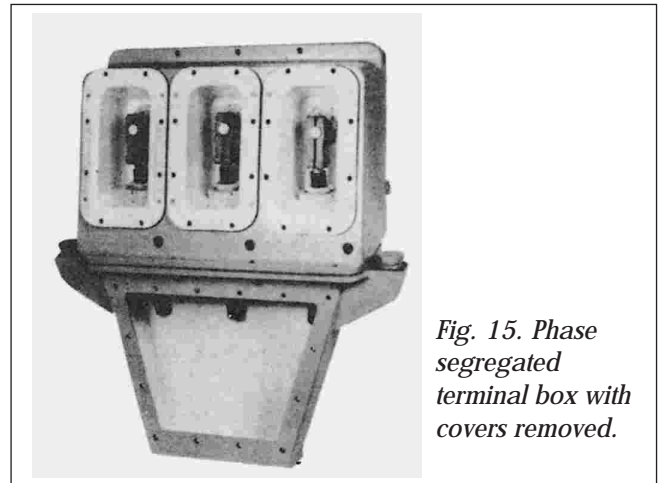


Fig. 15. Phase segregated terminal box with covers removed.

Phase segregated terminal box (PSTB)

The increased size of high-voltage electrical distribution systems has led to demands for a terminal box that is safe

Neutral Point terminal box (NPTB)

For star connected stator with six lead facility we can provide neutral point terminal box.

Finish

Standard machines are suitable for tropical conditions and for chemically contaminated conditions and for chemically contaminated environment considered non-hazardous to the personnel.

Standard treatment includes initial shot blasting and/or degreasing of all components which are subsequently painted and the priming of all ferrous surfaces with red oxide primer.

Stator frames and windings receive a minimum two dip in chemical resistance polyester impregnating varnish and heat-cured.

Rotors and internal surfaces of stator frames receive a

finishing coat of an air drying varnish.

External surfaces receive a final protection of two coats of a long-oil-alkyd base semi-gloss paint which is also applied to all fittings including plated or phosphate stained and oiled nuts, bolts but excluding self finished items. Normal colour of final paint is shade as per IS5.

Special chemically resistant epoxy paint system

This finish is recommended for all severely contaminated environment and essentially constitutes the substitution of amine-cured (two pack) epoxy paint for alkyd-base paints on all exposed surfaces.

Electrical Data

Standards and Specifications of Electrical Features

Standard Impak motor meets the requirement of relevant parts of following specifications.

Performance

Standard Impak motors comply with the requirement of IEC 34-1 and with BS 2613:1970, BS 4999 Part 4, 30, 31, 32, 41, 50, 51, 60, 69, 72 and Indian Standard IS 325.

Supply Voltage

Preferred voltage of high voltage machines are 3300 & 6600 volts.

However, machines can also be offered for any voltage system between 2000 volts and 11000 volts.

Voltage variation

Impak machines are normally suitable for voltage variation of $\pm 6\%$ and frequency variation of $\pm 3\%$. Machines suitable for supply variation of $\pm 10\%$ on voltage and $\pm 5\%$ on frequency with a permissible combined variation of $\pm 10\%$ can also be supplied on request.

If motors are required to operate continuously at voltage approaching limits of voltage tolerance without exceeding temperature rise limit, this must be specified in an enquiry. If nothing is specified then it will be presumed that temperature rise of 10°C higher than permissible limit is acceptable as permitted by relevant standards.

Voltage unbalance

Standard motors capable of operating under conditions of supply system unbalance providing the negative and zero phase sequence component of voltage do not individually exceed 2% of positive phase sequence component.

Waveform

The motors are also capable of operating on a supply where the waveform is such that the instantaneous values of 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 'Wave

form' conditions detailed in aforesaid paragraphs. Motors suitable for VSDs can be offered with special designs. For details please refer to works.

Ambient/Coolant Temperature

Standard machines are designed for ambient temperature of 40°C . When a motor is operated with cooling air at a temperature different from 40°C , the allowable temperature rise and corresponding output can be adjusted from the table below :

Table 5

Variation of output with Coolant temperature

Air temp.	Maximum temp. rise in K		Approx. permissible output (%)	
	80K	100K	80K list	100K list
Over 40°C upto 45°C	75	95	94	97
Over 45°C upto 50°C	70	90	86	92
Over 50°C upto 55°C	65	85	80	88
Over 55°C upto 60°C	60	80	74	84

Variation of Output with Altitude

Standard motors are designed for operation at any altitude from sea level to 1000 metres, when altitude is greater than 1000 metres then the following correction factors should be incorporated :

Table 6

Altitude from sea level (metres)	Max. temperature rise output		Approx. permissible output (%)	
	80K	100K	80K list	100 K list
1000	80	100	100	100
1500	76	95	95.5	97.5
2000	72	90	91	95
2500	68	85	87	92
3000	64	80	83	89

Duty, rating & general characteristics

Duty & rating

Standard rating

The standard rated outputs given are on the basis of 'Maximum continuous' or MCR, which indicates the load at which the motor can be operated for an unlimited period on continuous running duty corresponding to

duty-type S1 of IEC 34-1, IS 325 and BS4999 : Part 30. The motor rating plate will indicate 'MCR' or S1 and give the appropriate kW output and current for the rated load and speed.

Short time rating (STR)

For applications where it is known that the motor will only be required for a short period, with a long period 'at rest; and de-energised between operations-corresponding to duty-type S2 of IEC 34-1 BS4999 : Part 30 – reference should be made to the works. Consideration will be given to offering a motor with an STR rating which indicated the load at which the motor can be operated for a limited

Duty type rating (DTR)

Where motors are required to meet varying and cyclic loads, including periods of 'no-load' and 'at rest and de-energised' there will be difficulty in selecting a suitable MCR motor from the standard lists.

In such cases reference should be made to the works giving the load inertia (mr^2) referred to the motor and a load/time

period, starting from the ambient temperature.

The preferred times for short time ratings are 30 & 60 minutes. The motor rating rating plate will indicate 'STR' or S2 followed by the time in minutes and give the appropriate kW output and current for the rates speed.

sequence graph of duty. If the true load/time sequence is indeterminate an equivalent duty, no less onerous than the actual, should be selected from duty-types S3-S8 in IEC 34-1 or BS4999 : Part 30.

Motor rating plates will indicate the duty-type and the KW output and current for that rating.

General characteristics

Cage

Standard high voltage Impak cage motors comply with the requirements of BS4999 : Part 41 Design B.

Motor with other characteristics are available against specific enquiries.

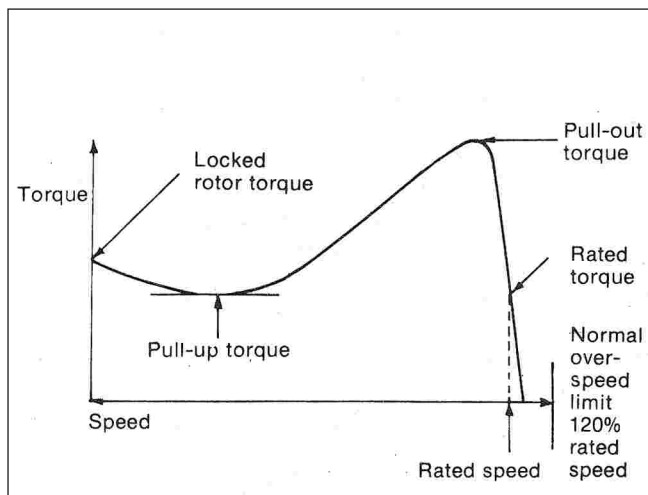


Fig. 16

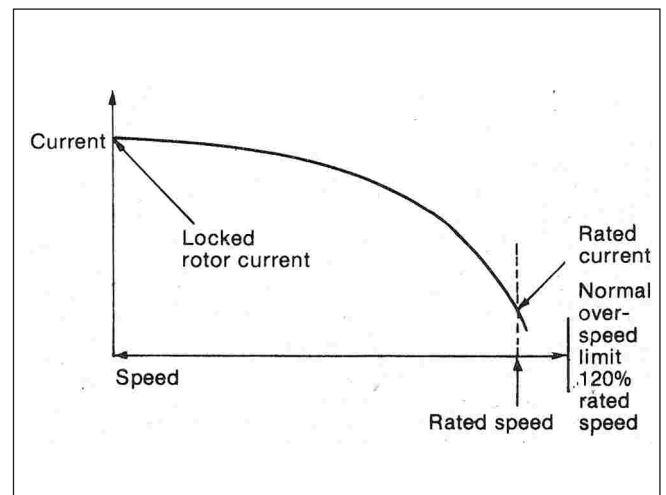


Fig. 17

Locked rotor kVA

The locked rotor kVA by 3 times the rated voltage, times the stator line current, with the rotor locked, expressed in kilo-volt amperes.

(To obtain the ratio of locked rotor current to rated load current, multiply the ratio given by p.u. efficiency and power-factor at rated load).

Table 7
Rated output

kW	Minimum ratio Locked rotor kVA Rated output kW
Over 40 up to 100	8, 2
Over 100 up to 250	7, 8
Over 250 up to 630	7, 6
Over 630 up to 1600	7, 4

Locked rotor torque

The locked rotor torque is the minimum measured torque which the motor will develop with the rotor locked and rated voltage applied, at rated frequency, expressed as the ratio of locked rotor torque to rated torque.

Table 8

Rated output kw	Minimum ratio					
	Locked rotor torque Rated torque					
	2 pole	4 pole	6 pole	8 pole	10 pole	12 pole
Over 40 up to 100	1, 25	1, 4	1, 3	1, 25	1,15	1,1
Over 100 up to 250	1, 0	1, 1	1, 2	1, 2	1,1	1,1
Over 250 up to 630	0, 8	0, 8	0,8	0, 8	0,8	0,8
Over 630 up to 1600	0, 6	0, 6	0, 6	0, 6	0, 6	0, 6

Pull-up torque

The pull-up torque is the smallest torque developed by the motor between zero speed and the speed which corresponds to the pull-out torque, when the motor is supplied at the rated voltage and frequency, expressed as the ratio of pull-up torque.

Table 9

Rated output kw	Minimum ratio					
	Pull-up torque Rated torque					
	2 pole	4 pole	6 pole	8 pole	10 pole	12 pole
Over 40 up to 100	0, 63	0, 7	0, 65	0, 63	0, 6	0, 55
Over 100 up to 250	0, 5	0, 55	0, 6	0, 6	0, 55	0, 55
Over 250 up to 630	0, 4	0, 4	0, 4	0,4	0,4	0, 4
Over 630 up to 1600	0, 3	0, 3	0, 3	0, 3	0, 3	0, 3

Wound rotor

Typical characteristics of wound rotor motors with additional external resistance.

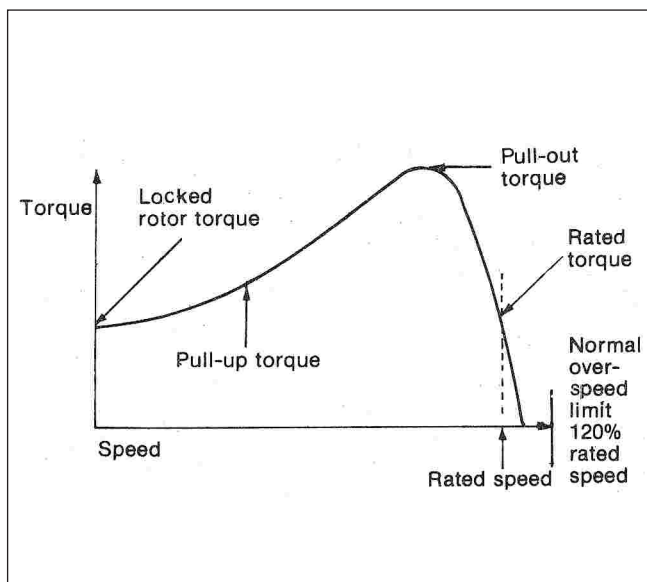


Fig. 18

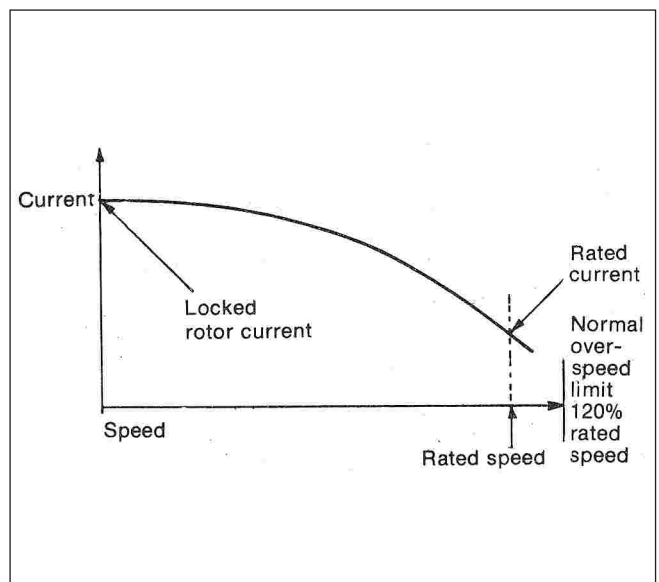


Fig. 19

Taking advantage of the facility to introduce extra resistance into the rotor circuit has the effect of-

- increasing the motor slip for a given torque output (and therefore reducing the speed) to a value which is a direct function of the ratio of total resistance to the rotor resistance.
- reducing the speed at which pull-out torque occurs, while the actual value of pull-out

torque remains unchanged. Under these conditions the rotor winding loss remains approximately the same, and extra losses occur in the external resistance. The heat losses in the motor are increased by a small amount due to iron losses in motor are increased by a small amount due to iron losses in the rotor, and the cooling effect, in the case of motors using shaft-mounted fans, is reduced. Therefore an allowance must be made in assessing the motor rating for the reduced speed and air flow in order that the permissible total temperature is not exceeded. This applies

particularly when the extra resistance is in the rotor circuit continuously.

The inherent relationship between torque and stator current makes it possible to select an external resistance value so as to produce a current/torque curve such that maximum torque (equal to pull-out torque) occurs at standstill, with a stator current 2, 5 (approx) times nominal full-load current, for motors having a pull-out torque approximately 2, 5 times full-load torque.

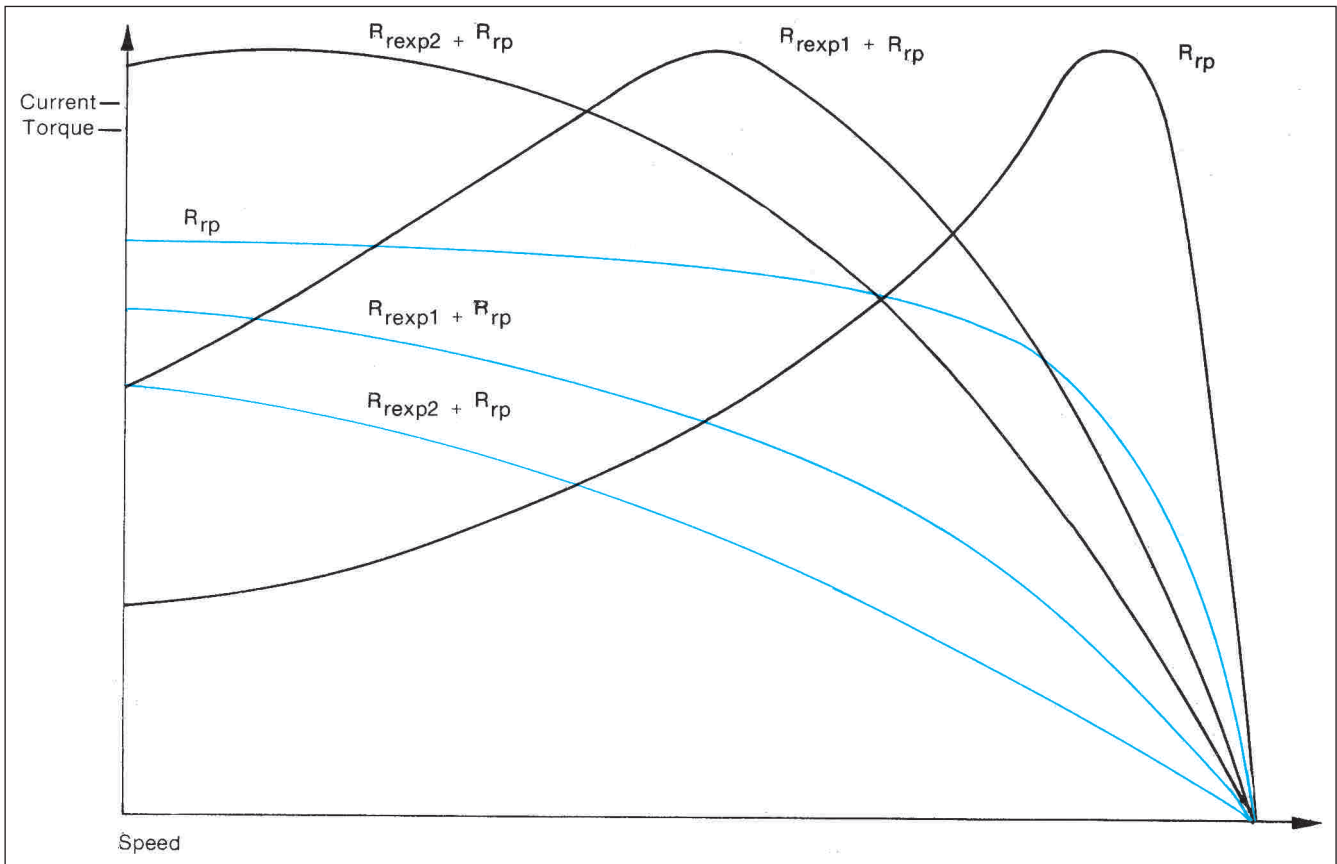


Fig. 20. Effect of external additional rotor resistance on speed torque and current curves

The additional external resistance may take different forms depending upon the required characteristics.

One example is a continuously rated resistance the value of which can be chosen to give full load torque at any required speed – although normally only used for relatively small changes. For a fixed value of torque output the energy loss in the external resistance is directly proportional to the

Frequency of starting

Unless specified otherwise standard cage motors are suitable for two starts in succession under specified conditions of load torque and inertia with the motor at its normal running temperature. The two starts, or attempted starts, should

Momentary overload

The motors are capable of withstanding, for not more than 15 seconds and without stalling or abrupt change in speed,

speed change. A typical drive application of motors with this type of resistance is a forming press where the peak stroke energy is delivered jointly by the motor and a fly wheel.

Another common example of a different type is a variable short time rated resistance used for starting and braking.

normally be followed by a cooling period of not less than 30 minutes. The frequency of starting of a wound rotor motor is completely dependent upon the duty requirements and must be specified.

a gradually applied excess torque of 0, 6 x rated torque.

Motor Speed

Standard design and performance figures are available for machines of 2, (cage only) 4, 6, 8, 10 and 12 pole speeds but high voltage Impak machines are available at speeds down to 20 pole.

For convenience the available synchronous speeds for the two most popular supply frequencies are given in Table 11.

The actual speeds are less than the synchronous speeds shown by the 'slip' where—

$$\text{Slip} = \frac{\text{Synchronous speed} - \text{Actual speed}}{\text{Synchronous speed}}$$

and is usually expressed as a percentage.

On the Impak range typical values of slip fall between 1 and 2%

Overspeed

Unless stated otherwise standard motors are designed to withstand an overspeed of 1, 2 x maximum rated speed.

Direction of rotation

Standard 2 pole motors are offered suitable for uni-directional rotation. However all 4 pole & above motors are offered with bi-directional rotation.

Table 10

Poles	r/min.	
	50Hz	60Hz
2	3000	3600
4	1500	1800
6	1000	1200
8	750	900
10	600	720
12	500	600
14	428	514
16	375	450
18	333	400
20	300	360

On motors fitted with silencers, external fans (as in IC0161) are also uni-directional, and the direction of rotation must be specified.

Methods of starting

Cage

Generally the choice of a particular starting method is based on application requirements rather than there being any preference by the motor manufacturer.

Direct-on-line starting is usual on the range of outputs covered by the Impak high voltage range and generally the only reason for departing from this is the need to reduce the starting current to an acceptable level as required by the supply system.

In certain special cases the choice of starting method may be dictated by the need for a smoother and more gradual start than would be obtained with direct-on-line starting.

All the major alternative methods work on the principle of applying to the stator of the motor a reduced voltage and increasing it during the start to the full line value.

As a general rule, the larger the number of voltage steps, the more expensive becomes the method.

In all cases closed transition starting is more expensive than the corresponding method of starting with open transition.

Table 12 summarizes the major starting methods with details of the starting torques and currents which apply.

Standard high voltage Impak motors are supplied with three terminals suitable for direct-on-line starting.

While they are generally also suitable for any of the alternative starting methods listed, with the corresponding reduction in starting torque and current, full details of starting requirements should be given in any enquiry or order.

Table 11

No.	Method of start	Voltage applied to motor	Starting torque	Starting current	Nature of starting duty	Torque	Number of starts per hour	Advantages	Disadvantages
		% DOL value	% DOL value	% DOL value					
1	Direct-on-line	100	100	100	Rapid start at maximum available	Fixed at maximum	Not usually limited	cheapest, simplest, and most reliable	High starting current
2.	Primary resistance	50	25	50	Smooth start at reduced torque	Adjustable by varying the resistance	Limited by resistor rating	Easily improvised Adjustable to suit load characteristic	Low torque to Current ratio Energy loss in resistor
		80	64	80					
3.	Auto Transformer (open transition)	50	25	25	Light starting	Tappings adjustable to suit load	Limited by transformer rating	Tappings adjustable to suit load	Costly Possibly high transients on higher tappings
		65	42	42	Normal starting				
		80	64	64	Heavy starting				
4.	Auto transformer (closed transition)	50	25	25	Light starting	Tappings adjustable to suit load	Limited by transformer rating	Much smoother transition peaks	Costly extra transformer insulation
		65	42	42	Normal starting				
		80	64	64	Heavy starting				

Starting schemes using vacuum contactors and breakers

High voltage Impak motor designs are such that they are suitable for use with starting schemes using vacuum if the design of the contactor is such that the motor is not exposed to excessive transient voltages. In general, this means that 3, 3 kV applications are suitable without surge suppressors. On 6,6kV systems, surge suppressors must be fitted on all vacuum switching devices when the motor duty involves regular inching. In addition, suppressors must be fitted when the motor output is less than 600 kW.

Restarting

The motors are capable of being restarted, after supply interruption, with up to 100% residual voltage on the motor at 180 out of phase. If continual reversing is required this must be stated in any enquiry.

Wound rotor

Wound rotor motors are normally started by means of a short time rated variable resistance on the rotor circuit. The resistance may be graduated in as many steps as are economic

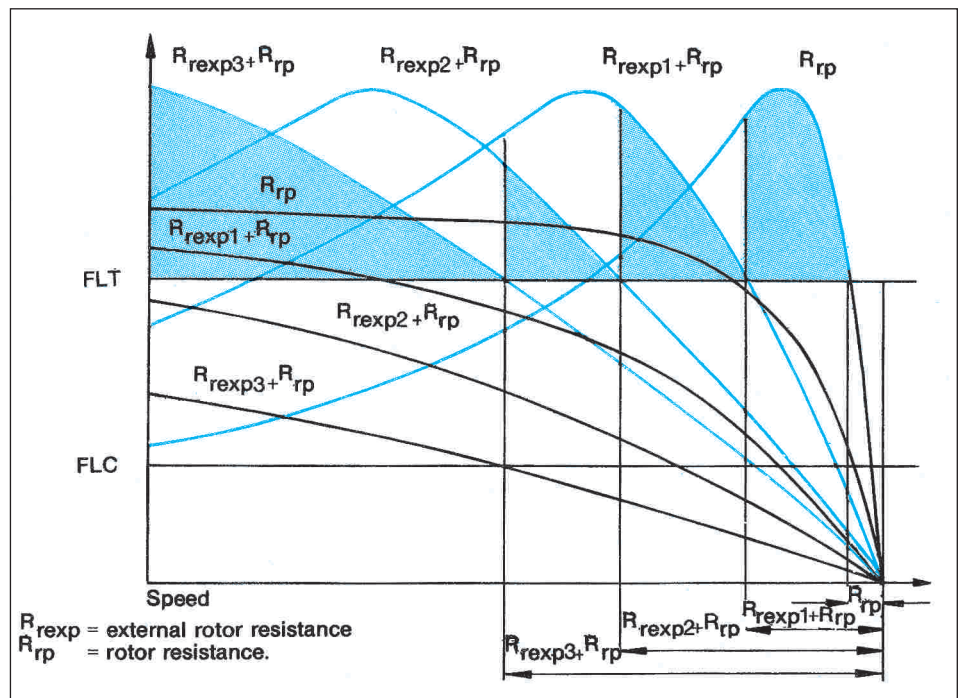


Fig. 21. The increase in torque at start by the use of different values of additional rotor resistance.

consistent with the current/torque requirements or may be 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 maximum torque with a stator current 2,5 (approx) times nominal full-load current for motors having a pull-out torque approximately 2,5 times full load torque.

Calculation of external starting resistance required for specific starting torque

- If R_{rexp} = external rotor resistance per Phase required to give a torque T_a at stand still (ohm)
- V_{roc} = rotor open-circuit voltage (volt)
- I_{rf} = rotor current at rated output (amp)
- T_f = torque at rated output
- T_a = torque required at standstill
- R_{rp} = 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 lie in the regions of 0,6 and 1,0. Low values result from large line voltage drops and high machine reactances, and vice versa.

$$R_{\text{rexp}} = k \frac{V_{\text{roc}}}{\sqrt{3} I_{\text{rf}}} \times \frac{T_f}{T_a} - R_{\text{rp}}$$

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 —

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

Multi-speed motors

Multi-speed Impak motors can be supplied to suit most applications

Cage

Two-speed motors

Two distinct and separate can be achieved by three methods —

Two separate windings

While theoretically, with two separate windings, it is possible to design motors with any two pole numbers in practice it is unusual to have ratios of more than 4 : 1 eg 4/16, 6/24 poles.

The wider the speed ratio the more the design departs from the optimum for each speed and as a consequence the performance of one or both speeds is inferior to that of the

single speed equivalent.

Two-speed motors with two separate windings are more expensive than the two alternative types of motor described below but are not as restricted in the available combinations of the two speeds.

Star-delta starting may be possible on both speeds...

Single winding – tapped (Dahlander connection)

This type of winding is possible for any pole combination where the ratio is 2 : 1 eg 2/4, 4/8, 6/12 or 10/20 poles etc.

The whole of the winding is utilized on both speeds and

hence the frame size for the rating is usually smaller than with two separate windings.

Star-delta starting is usually only possible on one of the speeds.

Wound rotor

Two-speed motors

Two distinct and separate speeds can be achieved by the use of two separate stator windings or by a single tapped

winding (Dahlander connection). Both as detailed for cage 2-speed motors.

Terminal markings, direction of rotation & connections

Terminal markings

Terminals for connection to the supply, or to a starter, are normally identified by letters and numbers in like with IS 4728-1975 but can be marked in accordance with any recognized standard.

Terminal markings on the stator and rotor connection diagrams, pages 19 to 22, are in IS 4728-1975.

The three phases of a primary (usually) stator winding are identified by –

U:V:W

End and intermediate points of a winding are identified by

a numerical suffix –

eg U1, U2, U3, U4

V1, V2, V3, V4

The three phases of a secondary (usually) rotor winding are identified by –

K:L:M

In a multi-speed motor the windings for each speed are indicated by a numerical prefix, the lowest number being the lowest speed.

Direction of rotation

Horizontal mounting motors

The direction of rotation is that observed when facing the shaft end.

On motors with two shaft extensions the direction of rotation is that observed when facing the shaft end at that end of the machine where the dimension C (shaft shoulder to centre of first fixing hole) is as listed in outline drawings enclosed at end of catalogue.

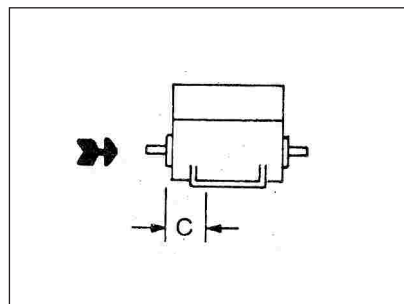


Fig. 22. Direction of rotation for horizontal mounting motors

Vertical mounting motors

The direction of rotation is that observed when the machine is viewed from the bottom, or flanges end.

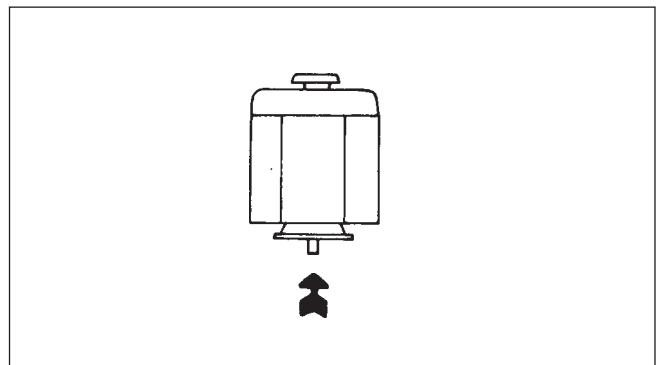


Fig. 23. Direction of rotation for vertical mounting motors.

Relationship between terminal markings and direction of rotation

The direction of rotation will be clockwise when the alphabetical sequence of the terminal letters of the phase

groups corresponds to the time sequence of the supply connected to the terminals.

Stator connections & terminal markings

Stator windings on the Impak range of high voltage motors are normally star connected. It is standard to have three stator leads to the terminal box and such cage motors are

suitable for starting direct-on-line or by primary resistance, auto transformer or induction regulator. Other requirements, involving additional terminals must be specified.

Single voltage/single speed

Three leads – star connected

Cage (DOL) Starter connects supply to U, V, W and would rotor

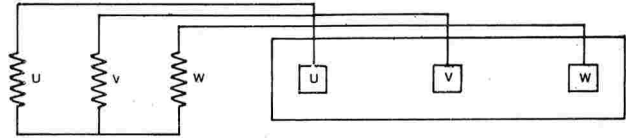


Fig. 24

Six leads – star connected

Cage (DOL) Star connected – Neutral point links – provided and starter connects supply to U1, V1, W1 would rotor

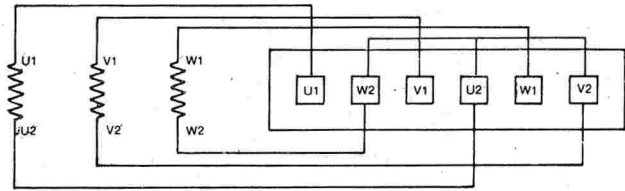


Fig. 25

Dual voltage/single speed

Voltage ratio 1 :2 (e.g. 3300/6600V)

Nine leads – star connected

Cage (DOL) Parallel star – Lower voltage links – provided, started connects supply to U1, V1, W1 and would rotor

Series star – Higher voltage links – provided, starter connects supply to U1, V1, W1

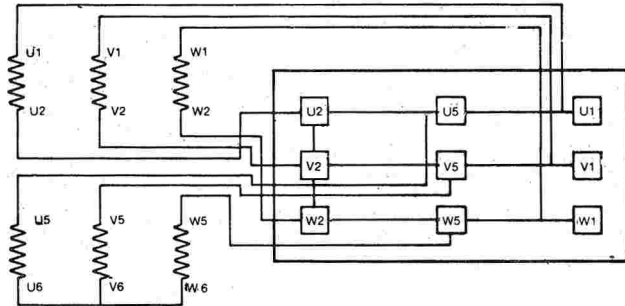


Fig. 26

Voltage ratio 1:1,73 (e.g. 2200/3300 V)

Six leads – delta/star connected

Cage (DOL) Delta – lower voltage links – provided, starter connects supply to U2, V2, W2 and would rotor

Series delta – higher voltage links – provided starter connects supply to U2, V2, W2

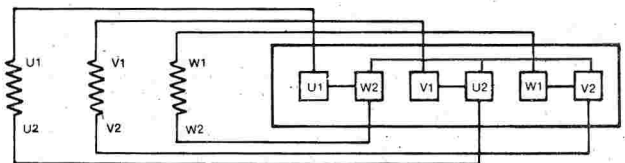


Fig. 27

Single voltage/dual speed

Two separate windings
Three leads each speed – star connected

Cage (DOL) Low speed starter connects supply to 1U, 1V, 1W and would rotor

High speed – starter connects supply to 2U, 2V, 2W

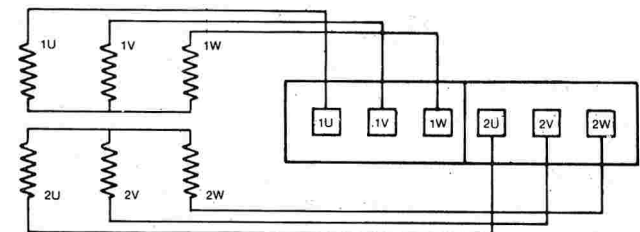


Fig. 28

Tapped winding
Six leads – star connected

Cage (DOL) and would rotor
Low speed-starter connects supply to 1U, 1V, 1W
High speed – starter connects together 1W, 1V, 1U and supply to 2U, 2V, 2W

Note – Changing speed reverses rotation. Standard rotation applies on high speed. To maintain standard rotation of low speed the starter should be arranged to reverse two-supply leads.

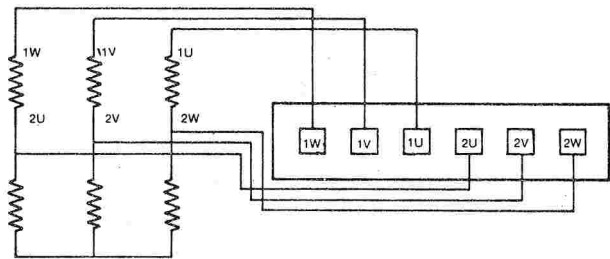


Fig. 29

Tapped winding
Six leads –
star connected – high speed
delta connected – low speed

Cage (DOL) and wound rotor
Low speed – starter connects supply to 1U, 1V, 1W
High speed – starter connects together 1W, 1V, 1U and supply to 2U, 2V, 2W

Note : Changing speed reverses rotation. Standard rotation applies on high speed. To maintain standard rotation on low speed the starter should be arranged to reverse two-supply leads.

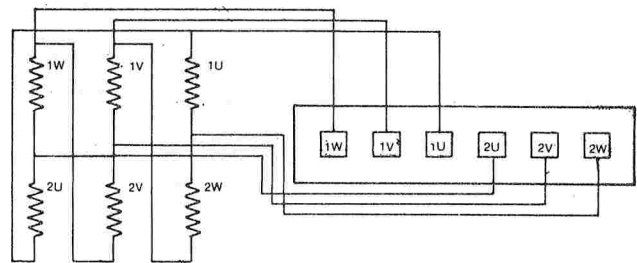


Fig. 30

Rotor connections and terminal markings

Rotor connections on Impak would rotor motors are contained in a terminal box separate from the stator connections.

Single speed

Three leads star connected

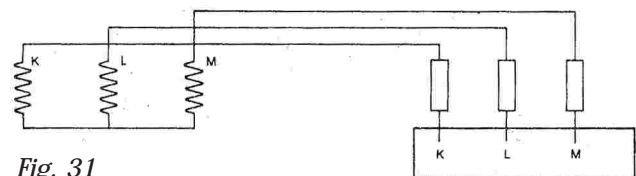


Fig. 31

Three leads delta connected

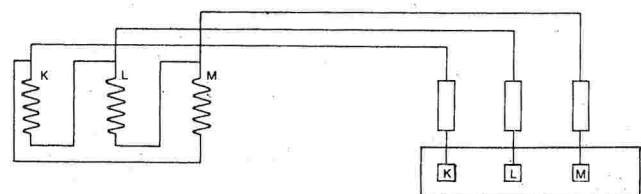


Fig. 32

Dual speed

Two separate windings six leads star connected.

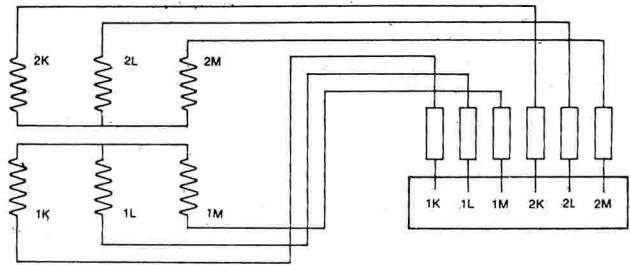


Fig. 33

Two separate windings six leads delta connected.

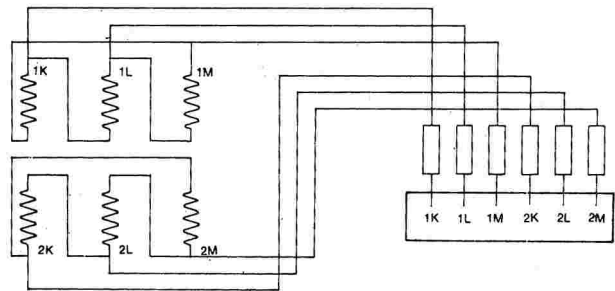


Fig. 34

Tapped winding six leads star connected.

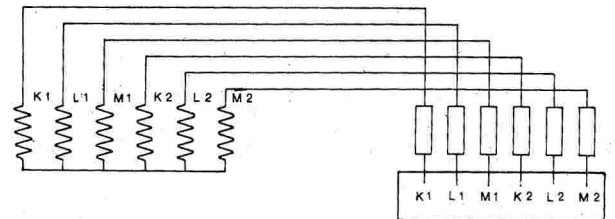


Fig. 35

Auxiliary connections and terminal terminal markings

Auxiliary terminals, contained in either the main or auxiliary terminal box are identified as;

Table 12

Thermistors	T 1, T 3&T C4 etc.
Thermocouples	TC1 & T C2 T C3 & T C4 Highest suffix denotes positive terminal
Resistance temp detectors	TR one only TR1 TR1 TR2 TR2 etc
Heaters	HE He Single voltage (single-phase or d.c.) HE1 HE2 HE3 Single-phase (or d.c.) tapped for dual voltage HE1 HE2 HE5 HE6 Single-phase sectionalised for dual voltage HE, HE, HE Three-phase heater

Specific connection diagrams supplied with machines having auxiliary terminals relate the terminal markings to the position of the particular device in the machine (e.g. bearings,

air circuit of windings). All auxiliary terminal fittings, in either main or auxiliary terminal box, have provision for earthing screened leads (as on thermocouples).

Windings & insulation

Stator windings

The standard insulation system used on Impak high voltage motors is Class 'F' for both 3.3 kV and 6.6 kV motors. The

coils are diamond-ended, two layer whole coil lap, with hard cell construction.

Coil design and manufacture

High voltage coils are manufactured from high conductivity copper, chosen to suit each application in terms of cross-sectional area, with thickness ratio, corner radius, hardness and ductility. The copper is coated with an enamel (polyester or polyesterimide depending on class of index, followed by a varnish bonded glass covering applied over the enamel mainly provided for mechanical protection but also for a secondary dielectric.

the coil nose is formed to give the required drop and overhang. Careful inspection at this stage ensures a set of coils which can be wound easily into the stator core.

The main insulation between the bonded conductor stack

The first operation in the manufacturing schedule is to wind the coil loop. The finished coil loop is shown in Fig. 36.

The wound coil loop are then "stack bonded" to produce a coil with a rigid straight slot portion and flexible endwinding. For Class F motors this is achieved by applying an epoxy resin, in the form of a resin glass tape, to what will become the straight portion of the coil consolidation, to form a rigid void free entity, achieved by heating and curing under pressure in a coil press. Prior to stack bonding, the end

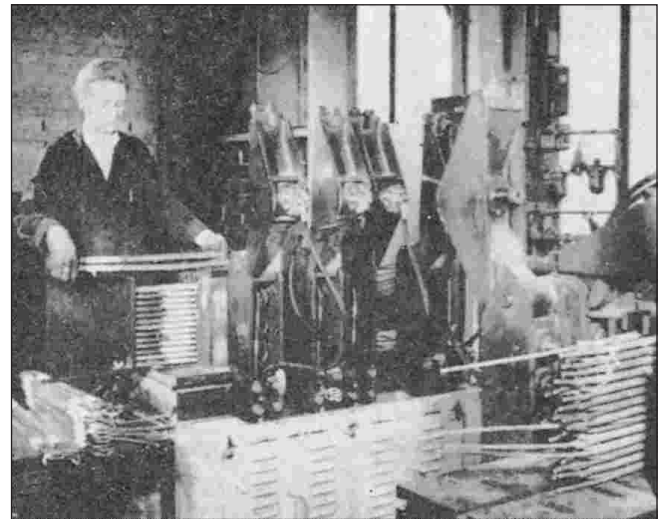


Fig. 37 Coil loops in multi-stack bonding presses.

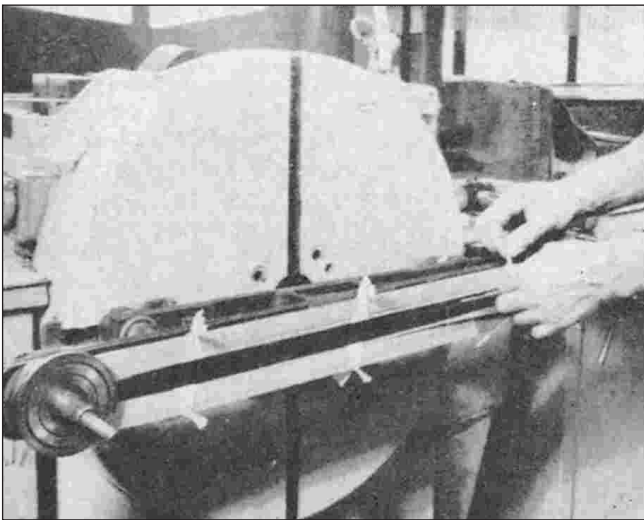


Fig. 36 Coil loop winding.

windings are covered with a fabric tape to hold and protect them, during subsequent operations. The tape is ultimately removed and replaced with insulating materials.

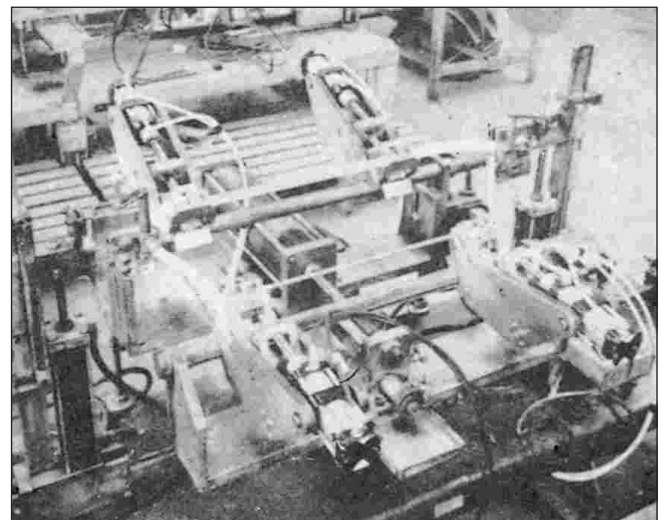


Fig. 38 Coil loops being pulled into their final shape.

Formation of the final coil shape is carried out by the coil forming equipment shown in Fig. 38. Here the stack bonded coil loop is pulled until the coil sides attain the positions they will finally occupy in the stator slots. At the same setting,

and the stator slot is now applied, in the form of mica-based materials chosen to suit the operating voltage and the type of suit the operating voltage and the type of construction i.e. hard or soft cell.

* Resin Poor or VPI system is also available for Impak Type Motors on request.

For 3.3 kV Cl-F insulation machines up to 4,2 kV, utilizes mica splittings bonded glass cloth backing, which is wrapped round the straight slot portion of the coil and taped in place as shown in Fig. 39. The original loop after proper shaping is applied with one layer of glass and backed and cured in Class F varnish before applying end winding insulators.

For higher operating voltages up to 7.0 kV having class F insulators, glass-backed micapaper containing poxy novolak-type resin, is applied to the coil straight portion to the required thickness. Heating under pressure cures the resin to form a solid dielectric, free of cavities and of an accurate size. Conducting varnish paint is applied on the straight paint of the coil to protect 70 cm corona discharge effect.



Fig. 39. Taping the straight slot portion of a coil having a soft cell construction.

Endwinding insulation is applied to complete the coil, in the form of polyester resin paint and half-lapped layers of polyester varnish-treated woven glass tape.

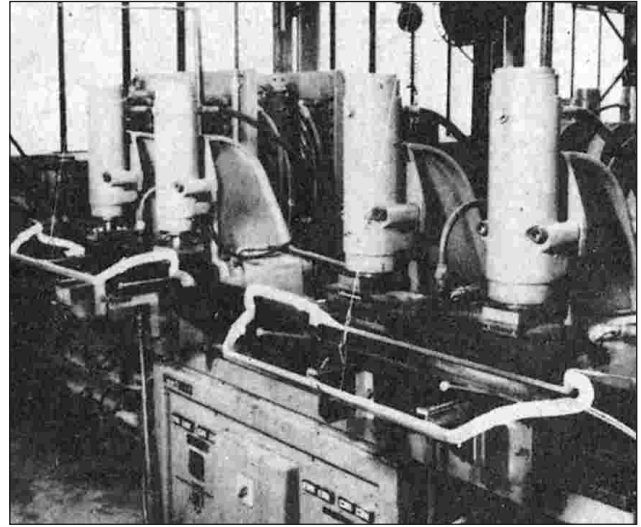


Fig. 40. Coil pressing to produce a hard cell.

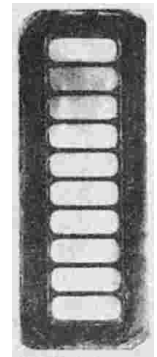


Fig. 41. A coil section showing the hard cell construction.

Coil testing (Resin Rich System)

To ensure the integrity of the finished winding, individual coils are tested, using the latest equipment to check for weakness or damage .

Interturn insulation is tested using a high voltage generator to pulse a damped sinusoidal voltage wave into the coil. The resultant waveform produced by the coil is displayed

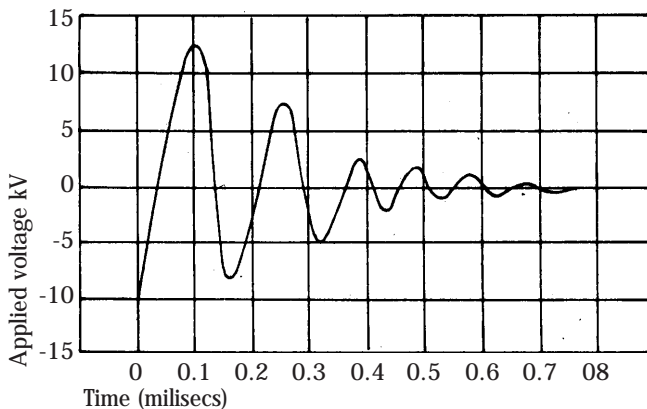


Fig. 42a. Satisfactory coil (i.e. no interturn fault)

on a storage oscilloscope, and can be compared readily with the waveform of a known good coil. The illustrations, Figs. 42a and 42b show the clear difference in wave form between an acceptable coil and a defective one.

To check the main ground insulation, a dielectric loss test is carried out a high voltage, using a Schering Bridge to determine values of the loss angle tans. A plot of applied voltage against tans generates a curve, the shape of which is an indicator of coil quality. Tan delta of coils are maintained in accordance with IS13508.

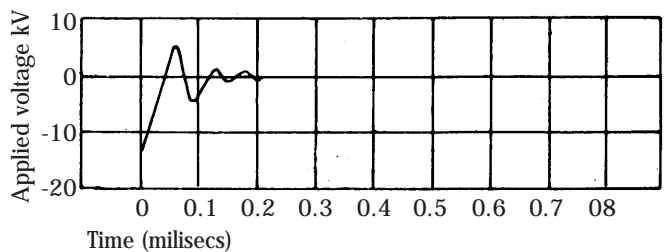


Fig. 42b. Unsatisfactory coil (i.e. no interturn fault)

Winding

Impak high voltage stator cores are of the open slot type, with the windings securely retained in the slots by wedges. Liners, fitted between the coil and the slot protect the coil from mechanical damage

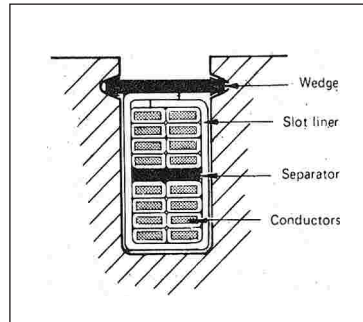


Fig. 43. Typical open slot section with windings in place for a 3.3 kV motor.

Bracing rings are fitted at each end of the core to support the endwindings, with additional resin-impregnated felt packings where required. Connections between coils and groups of coils are made at one end of the core, and the three phase connections made to the terminal box, using chlorosulphonated polyethylene-sheathed ethylene testing before connecting, and again after connecting, confirms the integrity of the insulation prior to impregnation.

Impregnation

The impregnation process consists of pre-heating the completely wound and connected stator, and dipping hot in a Class F isophalate polyester resin varnish, followed by curing. this cycle is repeated, giving a double treatment, injurious deposits and chemical contamination.

Rotor windings

Rotor windings are manufactured using the same materials and techniques as are employed for stator windings. They consist of half coils, comprising one or more conductors,

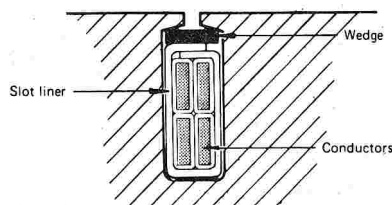


Fig. 46. Typical rotor slot section

wound in the form of a two-layer wage in semi-closed slots. Each end winding is supported by a glass-reinforced bracing

ring, with resin bonded glass fibre tape tension banding.

The three connections between the rotor coil groups and the slip-rings are made using chlorosulphonated polyethylene-sheathed ethylene propylene rubber-insulated cable.

A double impregnation in Class F polyester resin varnish is given, followed by curing, to protect against environmental conditions.

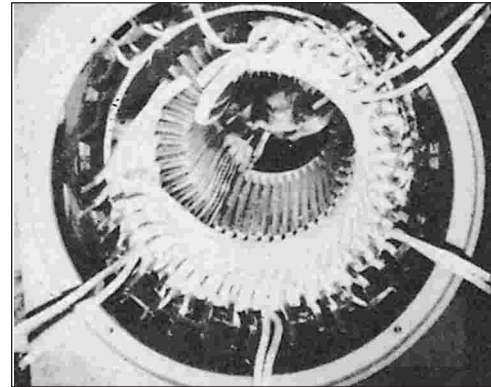


Fig. 44. A part wound stator showing the coils, slot liners wedges and separators.

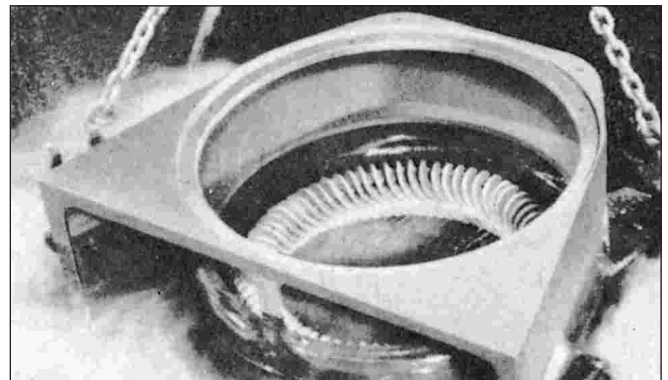


Fig. 45. A stator receiving the first of its two hot-dippings.

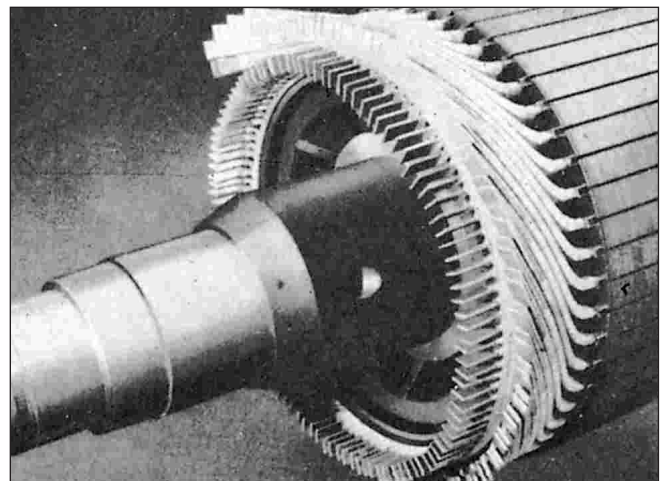


Fig. 47. A partly wound rotor showing a typical two layer copper strip winding.

Thermal protection

Various types of excess temperature sensing devices can be fitted, when specified to protect against primary and/or consequential damage to various components of the motor.

The different types of device provide varying degrees of protection against particular faults and the table below gives guidance on the selection of the most suitable device for the required protection.

The devices are described in detail on the following pages.

Table 14

Primary effect of fault	No.	Motor fault	Thermal protection device and location									
			— in cooling air circuit Thermistors — on stator end windings Thermocouples — in stator slot — on stator end winding — in cooling air circuit — in bearings Resistance elements — in stator slot — in air circuit — in bearings VP thermometers — in air circuit — in bearings									
Stator winding	1	Sustained overload	Good	Good	Good	Good	Good	Good	Good	Good	Code	
	2	Excessive duty cycle operation	Good	Good	Good	Good	Good	Good	Good	Good	Good	
	3	Prolonged reduced voltage	Good	Good	Good	Good	Good	Good	Good	Good	Good	
	4	Excessive ambient temperature	Good	Good	Good	Good	Good	Good	Good	Good	Good	
	5	Restricted ventilation, blocked filters, loss of cooling water	Average	Average	Average	Average	Average	Average	Average	Average	Average	
	6	Recirculating air	Average	Average	Average	Average	Average	Average	Average	Average	Average	
	7	Single phasing	Poor-little or no protection	Good	Good	Good	Good	Good	Poor-little or no protection	Poor-little or no protection	Poor-little or no protection	
	8	Stall	Poor-little or no protection	Good	Good	Good	Good	Good	Poor-little or no protection	Poor-little or no protection	Poor-little or no protection	
	9	Inertia too great. Starting overload	Poor-little or no protection	Good	Good	Good	Good	Good	Poor-little or no protection	Poor-little or no protection	Poor-little or no protection	
Bearings*	10	Thrust too high. Belt tension too high	No protection at all	No protection at all	No protection at all	No protection at all	Good	No protection at all	No protection at all	No protection at all		
	11	Loss of cooling water	No protection at all	No protection at all	No protection at all	No protection at all	Good	No protection at all	No protection at all	No protection at all		
	12	Incorrect lubricant	No protection at all	No protection at all	No protection at all	No protection at all	No protection at all	No protection at all	No protection at all	No protection at all		
	13	Loss of lubricant	No protection at all	No protection at all	No protection at all	No protection at all	Good	No protection at all	No protection at all	No protection at all		

* In the case of rolling-element bearings, the increase in heat that the devices can detect indicates that the bearing has failed or is failing and any action based on the indication of the device will usually only save consequential damage.

Non-indicating fixed temperature devices

Thermistors

Thermistors are semi-conducting resistance devices with a positive temperature co-efficient and with the reference temperature being fixed. They are used in conjunction with a relay unit in an alarm or trip circuit. Separate sets of thermistors are required for each function, i.e. trip and alarm.

Thermistors are normally located in stator endwindings, one to each phase.

Reference temperature – Where temperature limited to class B limits

Resistance elements (RTD)

A resistance element is a thermo-resistive device based on the phenomenon that the electrical resistivity of any metal increases as the temperature rises. They are used indirectly with an instrument either to indicate temperature or in an alarm and/or trip circuit.

Resistance elements can be used

- in stator slots (Type REX)
- in the air circuit (Type REY)
- or in the bearings (Type REZ)

In REX elements the resistance wire is wound on a former and mounted in a flat strip laminated plastic casing.

The tip sensitive element of Type REZ is enclosed in a metal sheath to protect it from damage due to vibration.

Platinum is the standard element material but copper is also available.

Trip – 140C (Type T 160)

Alarm – 120 (Type T 140)

Response to change in temperature - fast

Contacts (relay) - both normally open and normally closed i.e. changeover switch

Terminals - in either main or separate terminal box

Switching temperature - usually adjustable depends on instrument

Response to change in temperature - fast

Nominal resistance - 100 ohms at 0oC for platinum (53 ohms at 0oC for copper elements in Type REY and REZ)

Leads - two only is standard

Terminals - in either main or separate terminal box

Instruments - Marathon does not normally supply instruments for connection to resistance elements.

Bearing Temperature Detectors (BTDs)

BTDs are provided on request. Two types of BTDs are available i.e. (i) Dial Type BTD; (ii) Embedded Type

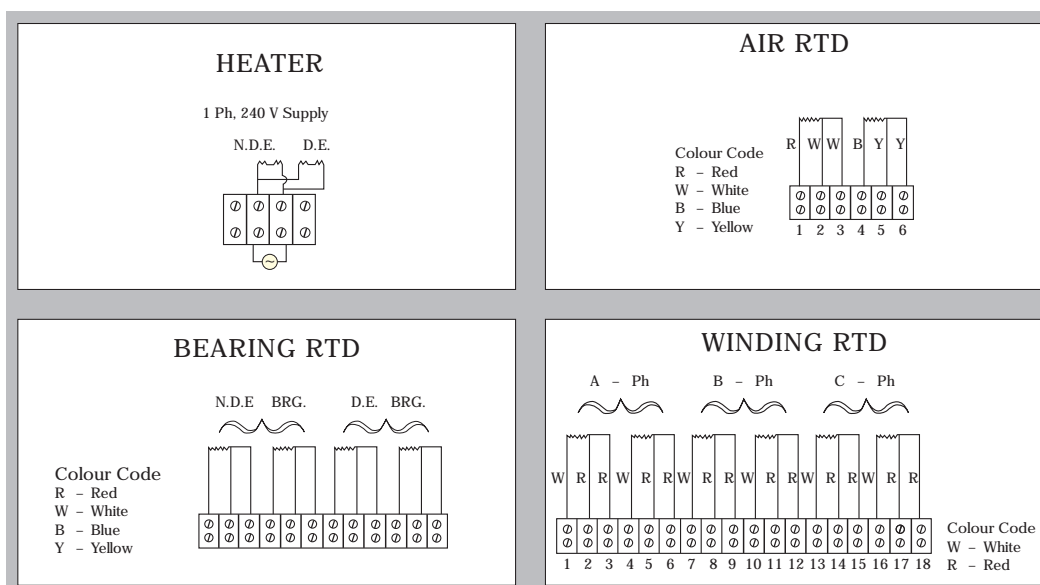


Fig 48 : Typical Wiring Diagrams for winding RTD, Bearing RTD and Space Heater

Anti-condensation heaters

Anti-condensation heaters can be provided, as a specified extra, on motors which may be subjected to wide variations in ambient temperature and humidity.

The heaters raise the temperature inside the motor to a few degrees above the dew point corresponding to the temperature and humidity of the ambient air and thus prevent the condensation of water inside the motor which would otherwise occur when the motor is not energised.

Normally heaters should be disconnected before the supply to the motor is switched on.

Heaters are normally mounted inside End-brackets and the

leads taken to terminal box.

Heater ratings and standard supply voltages are given in the table below.

Table 15
Heater Rating (Watts)

Frame	Volts (240V) –1Ø
355	180x2=360
400	225x2=450
450	280x2=560

Brushgear

Generally the continuous rated brushgear is fitted to Impak wound rotor induction motor, the degree of protection is provided according to enclosure requirement. Carbon

brusher are fitted as per the requirement. Generally M15E grade is provided. No. of brushes are selected on the basis of rotor current.

Special Components for Slipring Type Motors

Collector (Slipring)

Specially designed built up type sliprings with heavy duty construction are used. Sliprings are continuously rated.

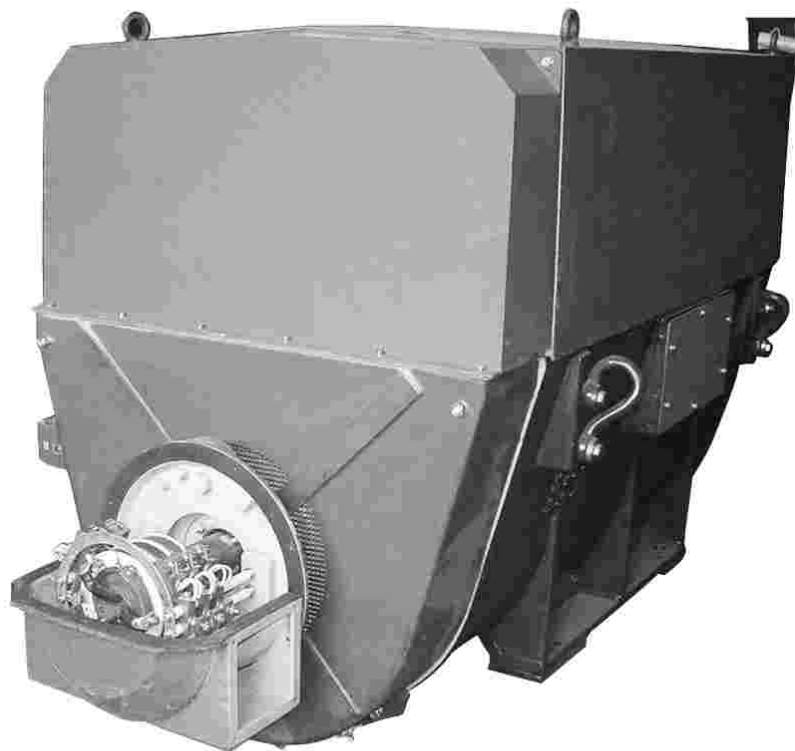


Fig. 49. Arrangement of Slipring Assembly of Impak Motors

marathon[™]
Motors



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